

authenticating step before accepting the bill such as in FIGs. 21-23 and 25, and 30-31.

For bills initially determined to be of a high value such as \$20, \$50, and \$100 bills, it may be desirable to perform two, three, or more denominating and/or authenticating steps such as in FIGs. 24 and 32-34.

- 5        Likewise, it may be desirable to perform additional denominating and/or authenticating steps in unattended currency handling machines such as unattended redemption machines. Additional screening steps may be desirable with these machines that accept money directly from customers such as bank customers or casino patrons for credit to their accounts or denomination exchanges as opposed to machines  
10      employed in environments where an employee such as a bank teller or casino employee receives money from customers and then the employee processes the bills with the aid of the currency machine.

- The above described embodiments of sensors and methods may be employed in currency discriminators such as, for example, those described above in connection with  
15      FIGs. 1, 2, 6-7, or the discriminator described in U.S. Pat. No. 5,295,196 incorporated herein by reference.

- The issuance of an error code such as a no call code or a suspect code may be used to suspend processing of a stack of bills, for example, as described in U.S. Pat. No. 5,295,196 incorporated herein by reference. These codes may cause the operation  
20      of a single or multiple output pocket discriminator to be suspended such that the bill triggering one of these codes is the last bill delivered to an output pocket before the operation of the discriminator is suspended. Accordingly, the triggering bill may be easily examined by the operator of the discriminator so that appropriate action may be taken based on the operator's evaluation of the triggering bill. Alternatively, in a  
25      multiple output pocket discriminator such as a two output pocket discriminator, the issuance of one of these error codes may cause triggering bills to be diverted to a different output pocket such as a reject pocket. Alternatively, bills that result in a no call code may be diverted to one output pocket and those that result in a suspect code may be diverted to a different pocket. Accepted bills may be routed to one or more  
30      other output pockets.

According to an embodiment of the present invention a number of selection elements associated with individual denominations are provided. In FIG. 1, these selection elements are in the form of keys or buttons of a keypad on a control panel 61.

Other types of selection elements such as switches or displayed keys in a touch-screen environment may be employed. The control panel 61 comprises a keypad and a display section. The keypad comprises a plurality of keys including denomination selection elements associated with different currency denominations, e.g., \$1, \$2, \$5, \$10, \$20, \$50, and \$100. The keypad also comprises a continuation selection element and a mode selection element. Various information such as instructions, mode selection information, authentication and discrimination information, individual denomination counter values, and total batch counter value are communicated to the operator via a display such as a LCD.

FIG. 35 is a flow chart illustrating the sequential procedure involved in the performing a sorting operation according to an embodiment of the present invention.

The operator of a currency discriminating device embodying a sorting method in accordance with the present invention selects a desired series or group of series to be off-sorted. For example, the operator may designate 1996-series \$100 bills as the desired denomination. Alternatively, the operator may designate \$100 bills that were issued prior to the 1996-series \$100 bills (old-series \$100 bills) as the desired series.

In embodiments wherein multiple series master patterns are stored for multiple denominations (e.g., new series \$100, \$50, and \$20 bills and "old" series \$100, \$50, and \$20 bills), the operator may designate all new series or all old series bills as the desired group of series of bills. Alternatively, in embodiments wherein multiple series master patterns are stored for multiple denominations, the operator may designate one or more bills as the desired group of bills based on their series and denomination (e.g., the operator may designate new series \$100, or new series \$100 and new series \$50, or old series \$100 and new series \$50 bills) as the desired series or group of series.

Alternatively, in embodiments wherein more than two series master pattern are stored for a given denomination, e.g., 1996-series \$100 bills (new series), 1980-series \$100 bills (mid-series), and 1950-series \$100 bills (old-series), one or more of the above and

one or more series of other denominations may be designated as the desired group of series.

A stack of currency to be processed is then placed in the input receptacle of the discriminator and the discriminator begins processing the bills. The discriminator  
5 determines the denomination and series of each bill in the stack. A bill whose denomination or series the discriminator is unable to determine to a requisite degree of certainty is termed a no call bill. The discriminator may also incorporate various authentication means. A bill failing one or more authentication tests is termed a suspect bill.

10 The procedure of FIG. 35 begins at subroutine step 900 and it is first determined whether the discriminator is expecting the current bill to be a bill having the desired or specified series (step 902). If the answer is no, processing proceeds to step 904 where it is determined whether the current bill is a bill of the desired series or group of series. If the answer is no, the value of the current bill is added to the total  
15 (step 906) and the subroutine is ended (step 908). If the answer is yes, the next bill is also expected to be a bill of the desired series and accordingly a flag bit is set indicating that the next bill is expected to be a bill of the desired series (step 910). Subsequently, a series change message is displayed (step 912) and a flag is set causing the discriminator to halt operation with the current bill being the last bill deposited in  
20 the output receptacle (step 914). A flag may be set to handle the processing of the first bill in the stack so that the discriminator will not halt if the first bill is of the specified series. The series change message indicates why the discriminator has stopped operating and aids in distinguishing from other reasons why the discriminator may have stopped such as the detection of a no call or suspect bill. According to one  
25 embodiment, when the discriminator flags a bill, the bill immediately upstream of the flagged bill is scanned by the discriminator before the discriminator halts and the flagged bill is the last bill output to the output receptacle. The value of the current bill is added to the total (step 906) and the subroutine is ended (step 908).

Returning to step 902, if the current bill is expected to have the desired series,  
30 i.e., the preceding bill was of the desired series, the subroutine branches to step 916 where it is determined whether the current bill indeed is of the desired series. If the

current does have the desired series, its value is added to the running total (step 906) and the subroutine ended (step 908). If at step 916 the current bill does not have the desired series, the expecting the desired series flag bit is reset (step 918), a series change message is displayed (step 912), and a flag is set causing the discriminator to  
5 halt operation with the current bill being the last bill deposited in the output receptacle (step 914). The value of the current bill is added to the total (step 906) and the subroutine is ended (step 908).

For example, assume the desired off-sort series is selected to be \$100 bills that are not 1996-series \$100 bills ("old" series \$100 bills) and a stack of bills having the  
10 following denominations and series is inserted into the input receptacle of a discriminator possessing an embodiment of the sorting operating mode according to the present invention: \$1 old-series, \$1 old-series, \$100 new-series, \$5 old-series, \$1 old-series, \$100 old-series, \$100 old-series, \$100 old-series, \$100 old-series, \$100 new-series, \$5 old-series, \$100 old-series, \$100 old-series, \$100 old-series. When the stack  
15 is placed in the input receptacle or hopper, the discriminating device may automatically start processing the bills or alternatively may require the selection of a start key. The currency discriminator processes the first six bills, discriminates their denomination and series, totals their values, and halts with the sixth bill, i.e., the first old-series \$100 bill, being the last bill in the output receptacle. Depending on the setup of the  
20 discriminator, the discriminator may halt after one or more bills upstream of the sixth bill are scanned but before they are output to the output receptacle. The operator then removes all six bills and separates the first five bills into one pile, e.g., pile A, and the sixth bill, namely, the old-series \$100 bill, into another pile, e.g., pile B. Depending on the setup of the currency discriminator, the discriminating device may continue to  
25 process the remaining bills automatically when the stack of six bills is removed or may continue processing the remaining bills when a continue element is selected. The discriminator then processes the next four bills, discriminates their denomination and series, adds their values to the running total, and halts with the tenth bill, i.e., the \$100 new-series bill, being the last bill output to the output receptacle. The operator  
30 may then remove all the bills from the output receptacle, placing the three old-series \$100 bills in pile B and the last new-series \$100 bill in pile A. The discriminator then

processes the next two remaining bills, discriminates their denomination and series, adds their values to the running total, and halts with the twelfth bill, i.e., the old-series \$100 bill, being the last bill output to the output receptacle. The operation then continues to proceed in the manner described above.

5        In an alternative embodiment, instead of halting the device with the flagged bill being the last bill output to the output receptacle, the device may halt with the flagged bill being at an identifiable location, e.g., the second to last bill output to the output receptacle, and the display may indicate the location of the flagged bill, e.g., "denomination changed with second to the last bill in the output bin."

10        In an alternative embodiment, bills of a designated series or group of series are separated from other bills using a series-stranger mode. Series-stranger mode is designed to accommodate a stack of bills all having the same series, such as a stack of 1996-series (or "new-series") \$100 bills. In such a mode, when a stack of bills is  
15        is determined and subsequent bills are flagged if they are not of the same denomination and series. Alternatively, the discriminator may be designed to permit the operator to designate the series or the series and denomination against which bills will be evaluated with those of a different series or a different series or denomination being flagged. For example, where a group of new and old series master patterns are stored for a  
20        number of denominations (e.g., new series \$100, \$50, and \$20, and old series \$1, \$2, \$5, \$10, \$20, \$50, and \$100 master patterns), either all new series bills or all old series bills may be designated. For example, if old series bills are designated, all new series bills, regardless of denomination will be treated as stranger bills. Alternatively, a combination or series and denominations may be designated so that all old series  
25        \$20s, \$50s, and \$100s will be flagged as stranger bills but all other bills are treated as non-stranger bills.

Assuming the first bill in a stack determines the relevant denomination and assuming the first bill is a new-series \$100 bill, then provided all the bills in the stack are new-series \$100 bills, the display of the discriminating device will indicate the  
30        aggregate value of the bills in the stack and/or the number of new-series \$100 bills in the stack. However, if a bill other than a new-series \$100 is included in the stack, the

discriminator will stop operating with the non-new-series \$100 bill or "stranger bill" being the last bill deposited in the output receptacle. The stranger bill may then be removed from the output receptacle and the discriminator is started again by depression of a "Continuation" key. An unidentified but otherwise acceptable new-series \$100  
5 bill may be handled by depressing a \$100 denomination selection element, or alternatively, the unidentified but otherwise acceptable new-series \$100 bill may be removed from the output receptacle and placed into the input hopper to be re-scanned. Upon the completion of processing the entire stack, the display will indicate the aggregate value of the new-series \$100 bills in the stack and/or the number of new-  
10 series \$100 bills in the stack. All bills of than new-series \$100 bills will have been set aside and will not be included in the totals. Alternatively, these stranger bills can be included in the totals via operator selection choices. For example, if a \$5 stranger bill is detected and flagged in a stack of new-series \$100 bills, the operator may be prompted via the display as to whether the \$5 bill should be incorporated into the  
15 running totals. If the operator responds positively, the \$5 bill is incorporated into appropriate running totals, otherwise it is not. Alternatively, a set-up selection may be chosen whereby all stranger bills are automatically incorporated into appropriate running totals.

While the invention is susceptible to various modifications and alternative  
20 forms, specific embodiments thereof have been shown by way of example in the drawings and herein described in detail. It should be understood, however, that it is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

We claim:

1. A method of denominating a currency bill as belonging to one of a plurality of recognizable denominations using a currency denominating device comprising the steps of:
  - 5 detecting the presence and location of a security thread in a currency bill under the control of a currency denominating device;  
denominating said currency bill as belonging to one of a plurality of recognizable denominations under the control of said currency denominating device by comparing the location of said detected security thread to master thread location  
10 information stored by said currency denominating device.
  2. The method of claim 1 further comprising the steps of:  
detecting the color of said security thread in a currency bill under the control of a currency denominating device;  
authenticating said currency bill under the control of said currency device by  
15 comparing the color of said detected security thread to stored master thread color information associated with the denomination determined by said denominating step.
  3. A method of denominating a currency bill as belonging to one of a plurality of recognizable denominations using a currency denominating device comprising the steps of:
    - 20 detecting the presence and color of a security thread in a currency bill under the control of a currency denominating device;  
denominating said currency bill as belonging to one of a plurality of recognizable denominations under the control of said currency denominating device by comparing the color of said detected security thread to master thread color information  
25 stored by said currency denominating device.
    4. The method of claim 3 wherein said step of detecting the color of any security threads comprises the step of illuminating said bill with visible light.
    5. The method of claim 3 wherein said step of detecting the color of any security threads comprises the step of illuminating said bill with ultraviolet light and detecting  
30 the color of any fluorescent light emitted from said security thread.

6. A method of denominating a currency bill as belonging to one of a plurality of recognizable denominations using a currency evaluation device comprising the steps of:
- detecting the magnetic zone printing pattern characteristics of a currency bill under the control of a currency denominating device;
- 5        denominating said currency bill as belonging to one of a plurality of recognizable denominations under the control of said currency denominating device by comparing the detected magnetic zone printing pattern characteristics to master magnetic zone printing pattern characteristics stored by said currency denominating device.
- 10 7. A method of denominating and authenticating a currency bill as belonging to one of a plurality of recognizable denominations using a currency evaluation device comprising the steps of:
- optically scanning a bill under the control of a currency denominating device to detect optical characteristics of said bill;
- 15        denominating said currency bill as belonging to one of a plurality of recognizable denominations under the control of said currency denominating device by comparing the detected optical characteristics to master optical characteristics stored by said currency denominating device;
- detecting security thread characteristic information from currency bill under the
- 20 control of a currency denominating device;
- authenticating said currency bill under the control of said currency device by comparing the detected security thread characteristic information to stored master thread characteristic information associated with the denomination determined by said denominating step.
- 25 8. The method of claim 7 wherein said thread characteristic information comprises thread location information.
9. The method of claim 7 wherein said thread characteristic information comprises thread color information.
10. A method of denominating and authenticating a currency bill as belonging to
- 30 one of a plurality of recognizable denominations using a currency evaluation device comprising the steps of:



detecting security thread characteristic information from currency bill under the control of a currency denominating device;

denominating said currency bill as belonging to one of a plurality of recognizable denominations under the control of said currency denominating device by

5 comparing the detected security thread characteristic information to stored master thread characteristic information;

optically scanning a bill under the control of a currency denominating device to detect optical characteristics of said bill;

10 authenticating said currency bill under the control of said currency device by comparing the detected optical characteristics to master optical characteristics stored by said currency denominating device associated with the denomination determined by said denominating step.

11. A method of denominating and authenticating a currency bill as belonging to one of a plurality of recognizable denominations using a currency evaluation device  
15 comprising the steps of:

detecting magnetic characteristic information from currency bill under the control of a currency denominating device;

denominating said currency bill as belonging to one of a plurality of recognizable denominations under the control of said currency denominating device by

20 comparing the detected magnetic characteristic information to stored master magnetic characteristic information;

optically scanning a bill under the control of a currency denominating device to detect optical characteristics of said bill;

25 authenticating said currency bill under the control of said currency device by comparing the detected optical characteristics to master optical characteristics stored by said currency denominating device associated with the denomination determined by said denominating step.

12. A method of denominating and authenticating a currency bill as belonging to one of a plurality of recognizable denominations using a currency evaluation device  
30 comprising the steps of:

optically scanning a bill under the control of a currency denominating device to detect optical characteristics of said bill;

optically denominating said currency bill as belonging to one of a plurality of recognizable denominations under the control of said currency denominating device by  
5 comparing the detected optical characteristics to master optical characteristics stored by said currency denominating device;

detecting security thread characteristic information from currency bill under the control of a currency denominating device;

denominating said currency bill under the control of said currency device by  
10 comparing the detected security thread characteristic information to stored master thread characteristic information;

accepting said bill if the denomination determined optically agrees with the denomination determined by comparing thread characteristic information; and

otherwise, rejecting said bill if the denomination determined optically does not  
15 agree with the denomination determined by comparing thread characteristic information.

13. A method of denominating and authenticating a currency bill as belonging to one of a plurality of recognizable denominations using a currency evaluation device comprising the steps of:

20 magnetically scanning a bill under the control of a currency denominating device to detect magnetic characteristics of said bill;

magnetically denominating said currency bill as belonging to one of a plurality of recognizable denominations under the control of said currency denominating device by comparing the detected magnetic characteristics to master magnetic characteristics  
25 stored by said currency denominating device;

detecting security thread characteristic information from currency bill under the control of a currency denominating device;

denominating said currency bill under the control of said currency device by comparing the detected security thread characteristic information to stored master  
30 thread characteristic information;

accepting said bill if the denomination determined magnetically agrees with the denomination determined by comparing thread characteristic information; and

otherwise, rejecting said bill if the denomination determined magnetically does not agree with the denomination determined by comparing thread characteristic

5 information.

14. A method of denominating and authenticating a currency bill as belonging to one of a plurality of recognizable denominations comprising the steps of:

retrieving first, second, and third characteristic information from a currency bill;

10 denominating said currency bill a first time as belonging to one of a plurality of recognizable denominations using first characteristic information, wherein said retrieved first characteristic information is compared to master first characteristic information associated with each of said plurality of recognizable denominations;

denominating said currency bill a second time as belonging to one of a plurality  
15 of recognizable denominations using second characteristic information, wherein said retrieved second characteristic information is compared to master second characteristic information associated with each of said plurality of recognizable denominations;

denominating said currency bill a third time as belonging to one of a plurality  
of recognizable denominations using third characteristic information, wherein said  
20 retrieved third characteristic information is compared to master third characteristic information associated with each of said plurality of recognizable denominations;

accepting said bill if the denominations as determined during said three denominating steps all agree; and

25 rejecting said bill if the denominations as determined during said three denominating steps do not all agree.

15. A method of denominating and authenticating a currency bill as belonging to one of a plurality of recognizable denominations comprising the steps of:

retrieving first and second characteristic information from a currency bill;

denominating said currency bill a first time as belonging to one of a plurality of  
30 recognizable denominations using first characteristic information, wherein said retrieved first characteristic information is compared to master first characteristic

information associated with each of said plurality of recognizable denominations;

authenticating said currency bill by comparing said retrieved second characteristic information to master second characteristic information associated only with the denomination determined by said first denominating step; and

5       rejecting said bill if said retrieved second characteristic information does not sufficiently match said master second characteristic information associated with the denomination determined by said first denominating step;

denominating said bill a second time if said retrieved second characteristic information sufficiently matches said master characteristic information associated with

10       the denomination determined by said first denominating step, wherein said second denominating step is performed by comparing said retrieved second characteristic information to master second characteristic information associated with each of said plurality of recognizable denominations and determining the denomination of said currency bill to be the denomination associated with the master second characteristic  
15       information which most closely agrees with said retrieved second characteristic information.

16.   The method of claim 15 further comprising the steps of:

accepting said bill if the denomination as determined during said second denominating step matches the denomination as determined during said first

20       denominating step; and

rejecting said bill if the denomination as determined during said second denominating step does not match the denomination as determined during said first denominating step.

17.   The method of claim 15 further comprising the steps of:

25       rejecting said bill if the denomination as determined during said second denominating step does not match the denomination as determined during said first denominating step;

retrieving third characteristic information from a currency bill;

30       if the denomination as determined during said second denominating step matches the denomination as determined during said first denominating step then:

authenticating said currency bill by comparing said retrieved third characteristic information to master third characteristic information associated only with the denomination determined by said first denominating step; and

5 rejecting said bill if said retrieved third characteristic information does not sufficiently match said master third characteristic information associated with the denomination determined by said first denominating step;

denominating said bill a third time if said retrieved third characteristic information sufficiently matches said master characteristic information associated with the denomination determined by said first denominating step, 10 wherein said third denominating step is performed by comparing said retrieved third characteristic information to master third characteristic information associated with each of said plurality of recognizable denominations and determining the denomination of said currency bill to be the denomination associated with the master third characteristic information which most closely 15 agrees with said retrieved second characteristic information;

accepting said bill if the denomination as determined during said third denominating step matches the denomination as determined during said first denominating step; and

20 rejecting said bill if the denomination as determined during said third denominating step does not match the denomination as determined during said first denominating step.

18. A method of denominating and authenticating a currency bill as belonging to one of a plurality of recognizable denominations comprising the steps of:

retrieving first and second characteristic information from a currency bill;

25 denominating said currency bill a first time as belonging to one of a plurality of recognizable denominations using first characteristic information, wherein said retrieved first characteristic information is compared to master first characteristic information associated with each of said plurality of recognizable denominations;

30 authenticating said currency bill by comparing said retrieved second characteristic information to master second characteristic information associated only with the denomination determined by said first denominating step; and

if said retrieved second characteristic information does not sufficiently match said master second characteristic information associated with the denomination determined by said first denominating step then:

denominating said bill a second time if said retrieved second  
5 characteristic information does not sufficiently match said master characteristic information associated with the denomination determined by said first denominating step, wherein said second denominating step is performed by comparing said retrieved second characteristic information to master second characteristic information associated with each of said plurality of recognizable  
10 denominations and determining the denomination of said currency bill to be the denomination associated with the master second characteristic information which most closely agrees with said retrieved second characteristic information;  
and

rejecting said bill.

15 19. The method of claim 18 further comprising the step of:  
accepting said bill if said retrieved second characteristic information sufficiently matches said master second characteristic information associated with the denomination determined by said first denominating step;

20 20. The method of claim 18 further comprising the steps of:  
retrieving third characteristic information from a currency bill;  
wherein if said retrieved second characteristic information sufficiently matches said master second characteristic information associated with the denomination determined by said first denominating step:

25 authenticating said currency bill by comparing said retrieved third characteristic information to master third characteristic information associated only with the denomination determined by said first denominating step; and  
accepting said bill if said retrieved third characteristic information sufficiently matches said master third characteristic information associated with the denomination determined by said first denominating step;

30 otherwise:

denominating said bill a third time if said retrieved third characteristic information does not sufficiently matches said master characteristic information associated with the denomination determined by said first denominating step, wherein said third denominating step is performed by comparing said retrieved third characteristic information to master third characteristic information associated with each of said plurality of recognizable denominations and determining the denomination of said currency bill to be the denomination associated with the master third characteristic information which most closely agrees with said retrieved second characteristic information and rejecting said bill.

21. A currency discriminating apparatus comprising:
  - an input receptacle for receiving a stack of currency bills, each of said bills having a denomination associated therewith;
  - a transport mechanism for transporting said bills, one at a time, past a discriminating unit to at least one output receptacle;
  - said discriminating unit discriminating the denomination of said currency bills, said discriminating unit comprising a plurality of magnetoresistive sensors.
22. The currency discriminating apparatus of claim 21 wherein plurality of magnetoresistive sensors are arranged in an array.
23. The currency discriminating apparatus of claim 22 wherein plurality of magnetoresistive sensors are arranged in a linear array.
24. A currency discriminating apparatus comprising:
  - an input receptacle for receiving a stack of currency bills, each of said bills having a denomination and series associated therewith;
  - a transport mechanism for transporting said bills, one at a time, past a discriminating unit to at least one output receptacle;
  - said discriminating unit discriminating the series of said currency bills.
25. A method of sorting currency of a specific series using a device capable of discriminating the denomination and series of currency bills comprising the steps of:

receiving a stack of bills in an input receptacle, each bill having a denomination and series associated therewith;

transporting said bills, one at a time, past a series discriminating unit to at least one output receptacle;

5 discriminating the series of each bill; and  
sorting said bills according to their series.

26. A method of off-sorting currency of a specific series using a device capable of discriminating the denomination and series of currency bills comprising the steps of:

receiving a stack of bills in an input receptacle;

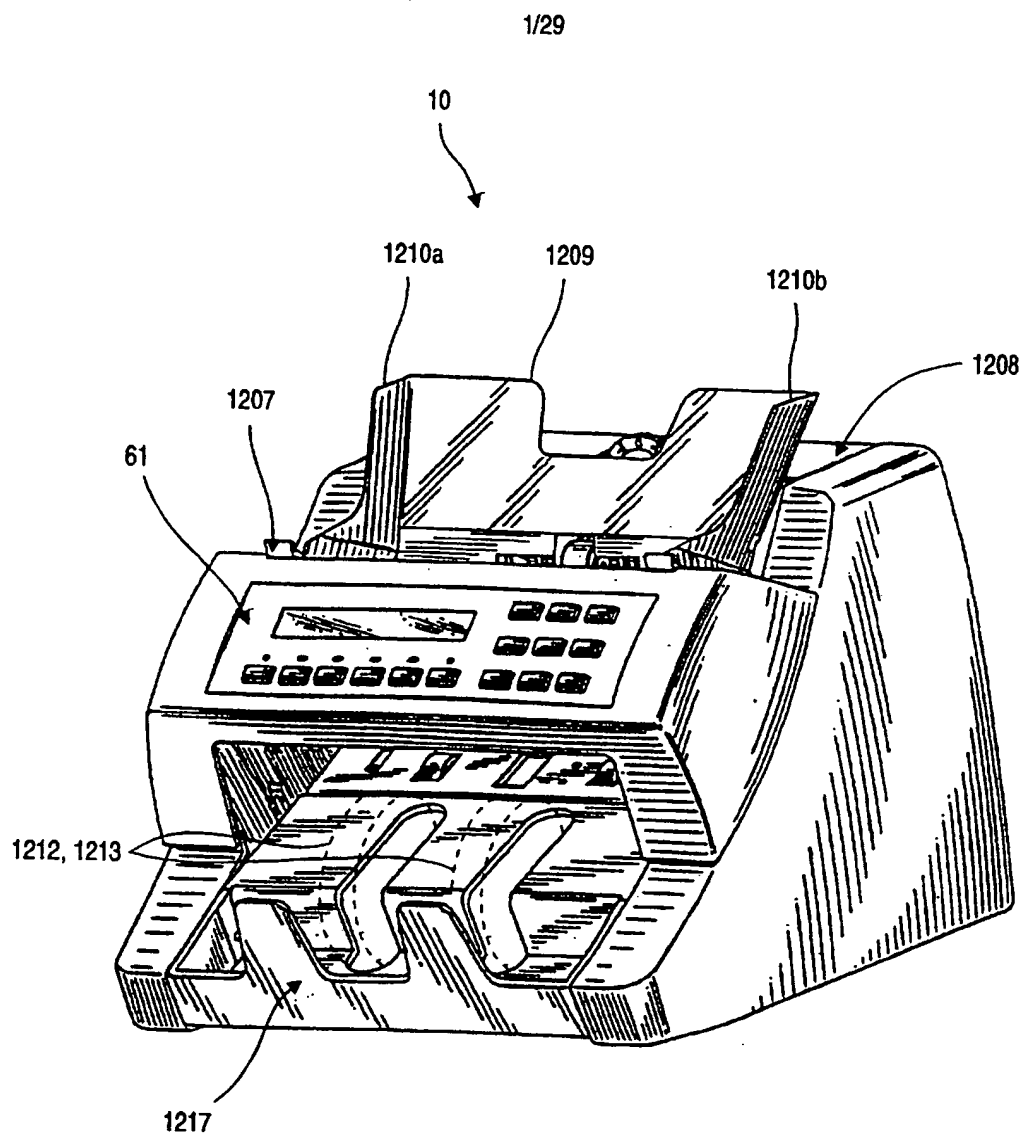
10 transporting said bills, one at a time, past a denomination and series  
discriminating unit to an output receptacle;

discriminating the denomination and series of each bill;

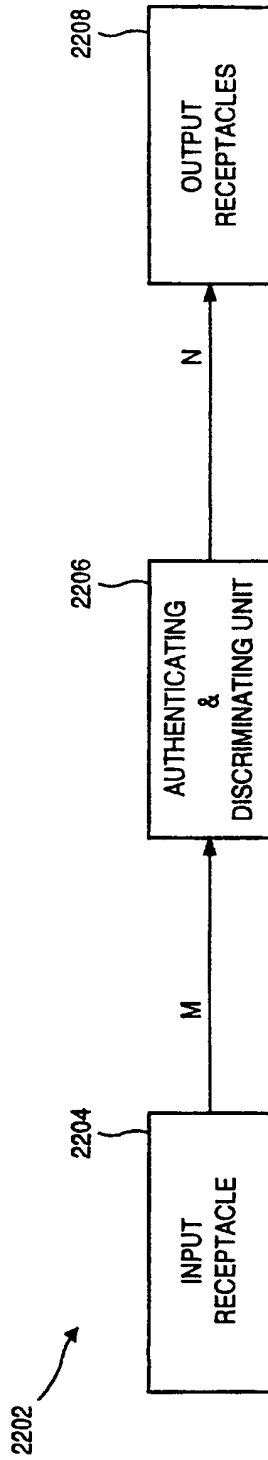
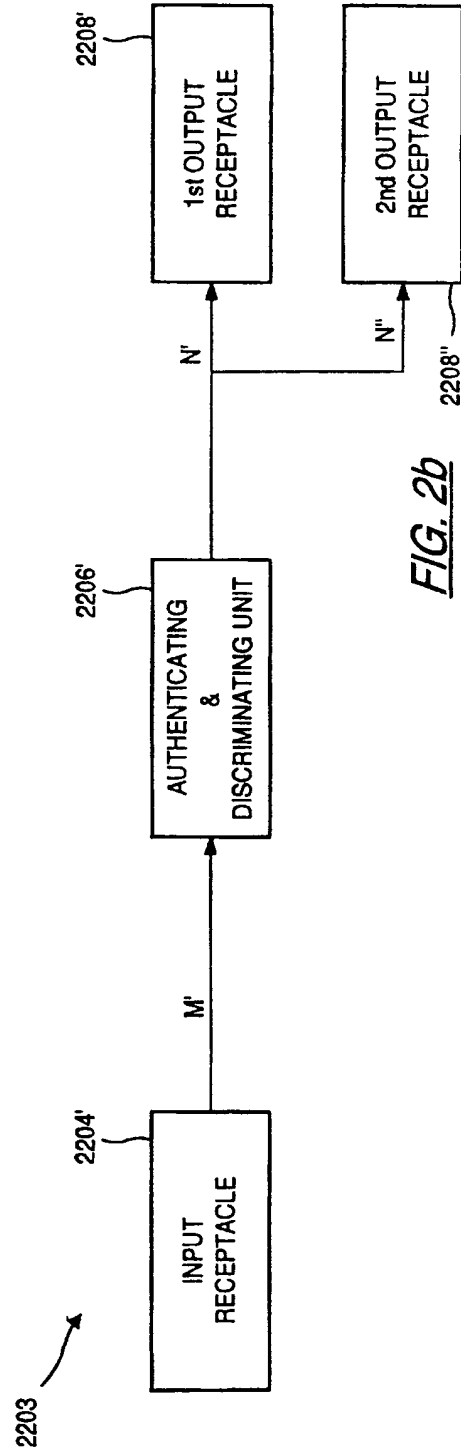
determining whether the series of a current bill is a specified series; and either

(1) halting operation of the device when said current bill does have said  
15 specified series and an immediately preceding bill does not have said specified series;  
(2) halting operation of the device when said current bill does not have said  
specified series and said immediately preceding bill does have said specified series; or  
(3) continuing operation of the device.

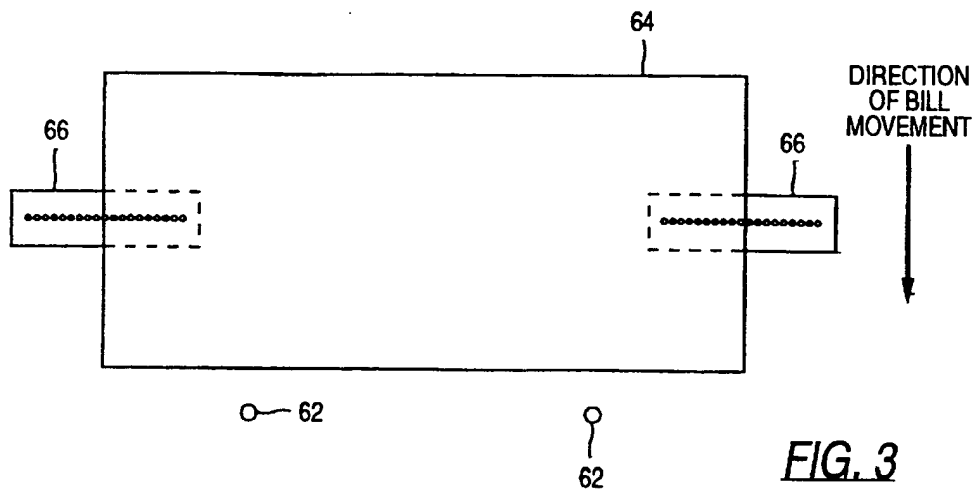




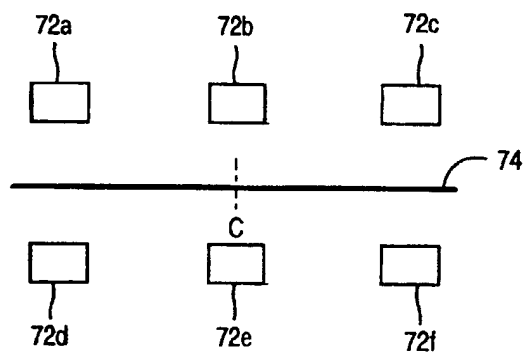
2/29

FIG. 2aFIG. 2b

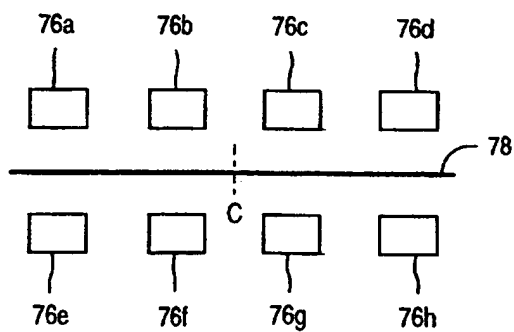
3/29



**FIG. 3**

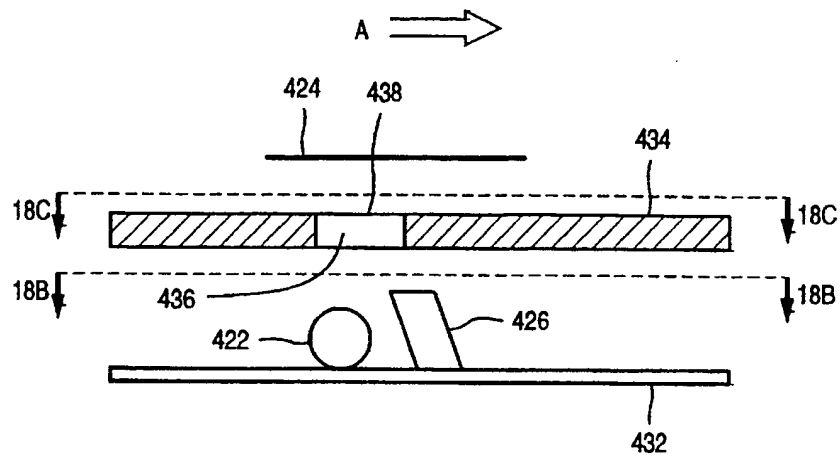


**FIG. 4**

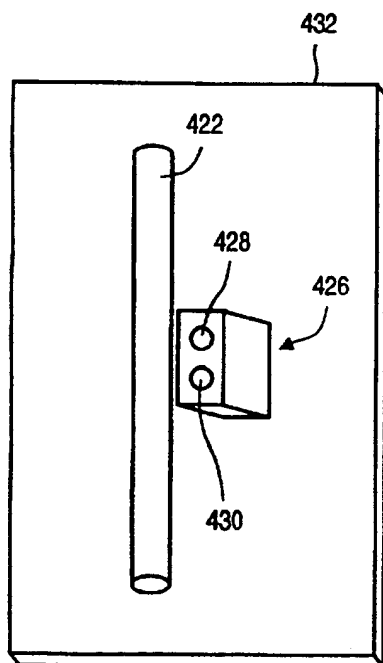


**FIG. 5**

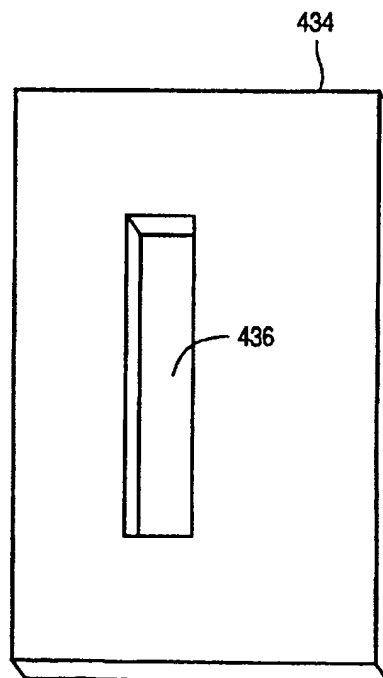
4/29



**FIG. 6a**



**FIG. 6b**



**FIG. 6c**

5/29

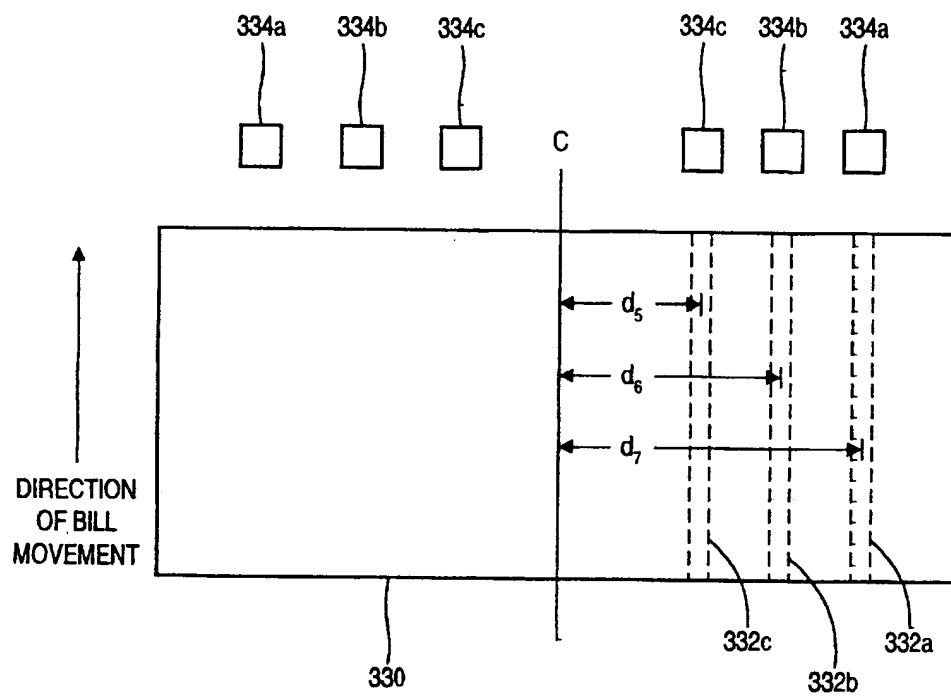
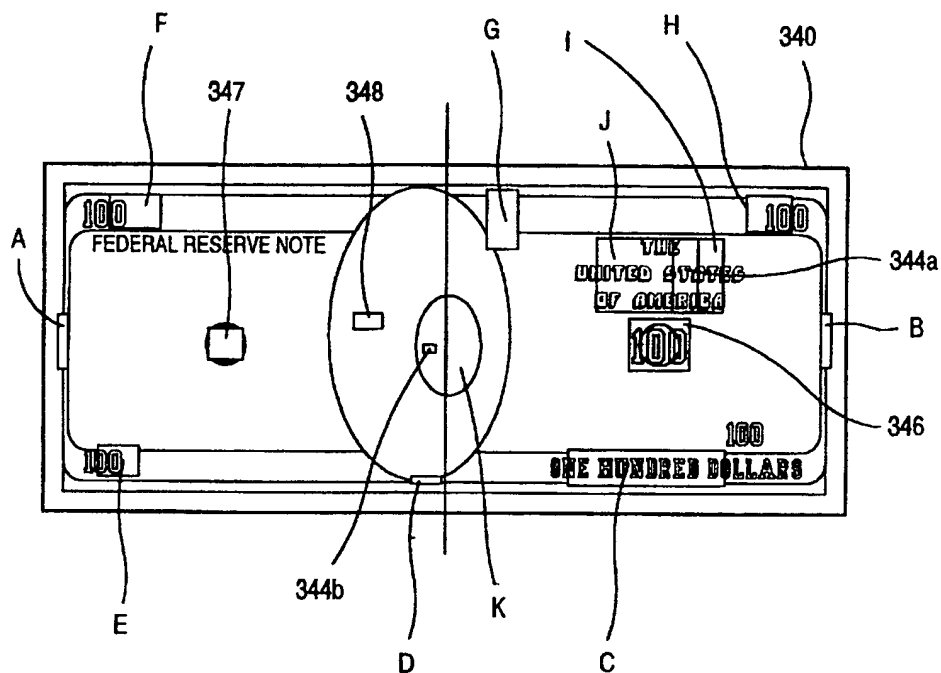
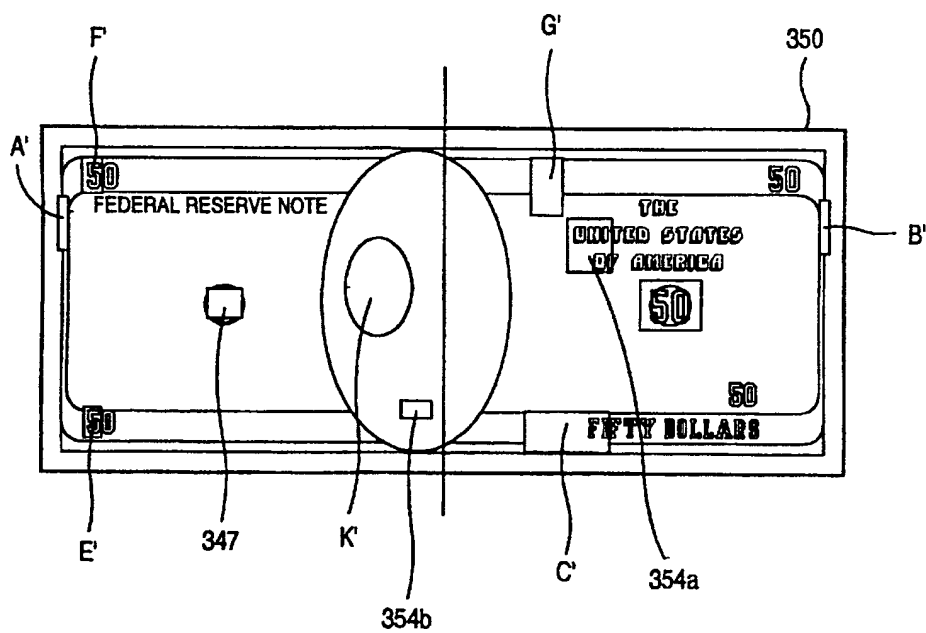


FIG. 7

6/29



**FIG. 8a**



**FIG. 8b**

7/29

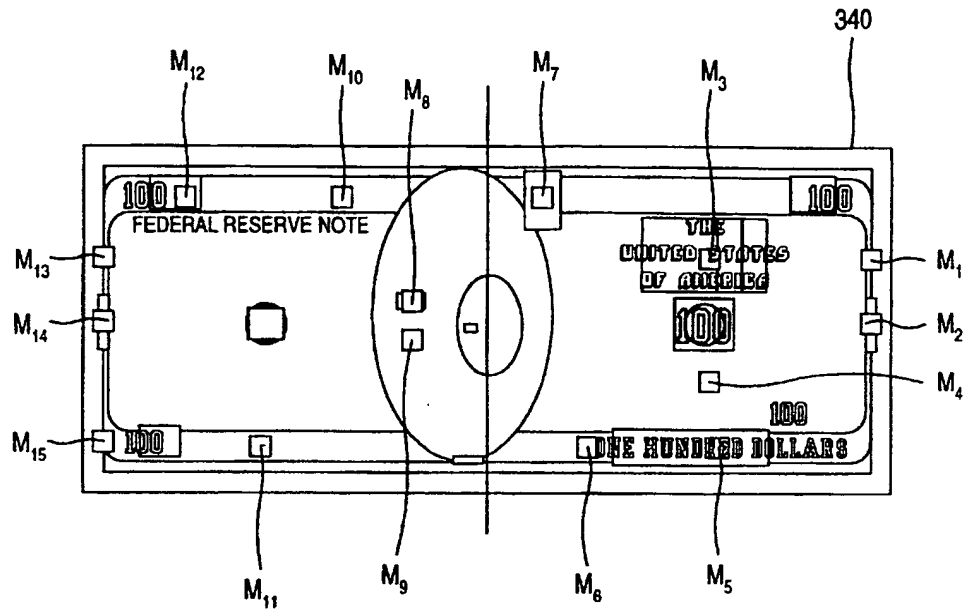


FIG. 9a

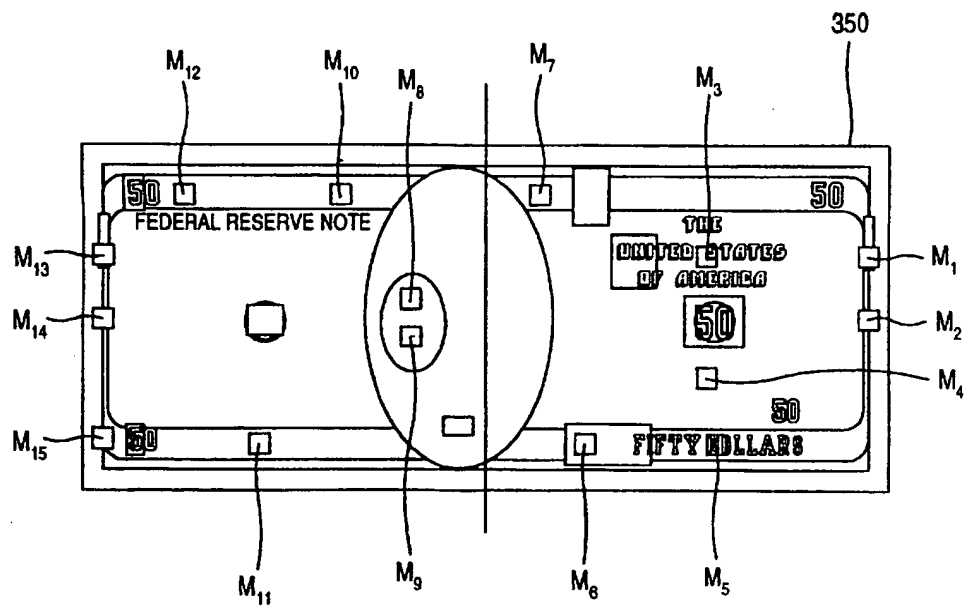
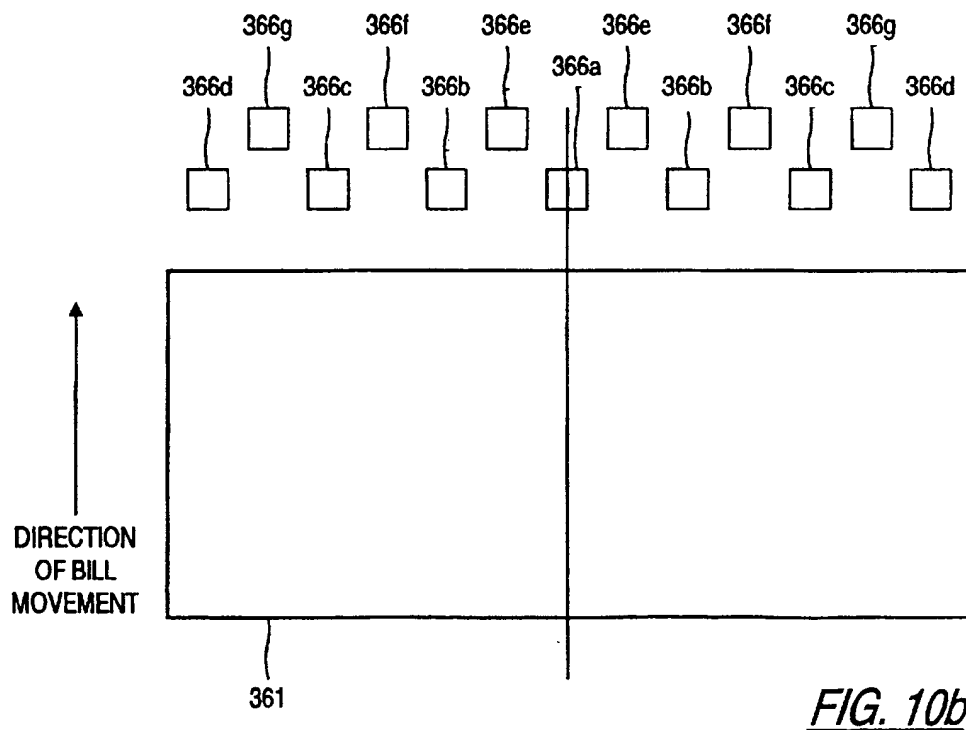
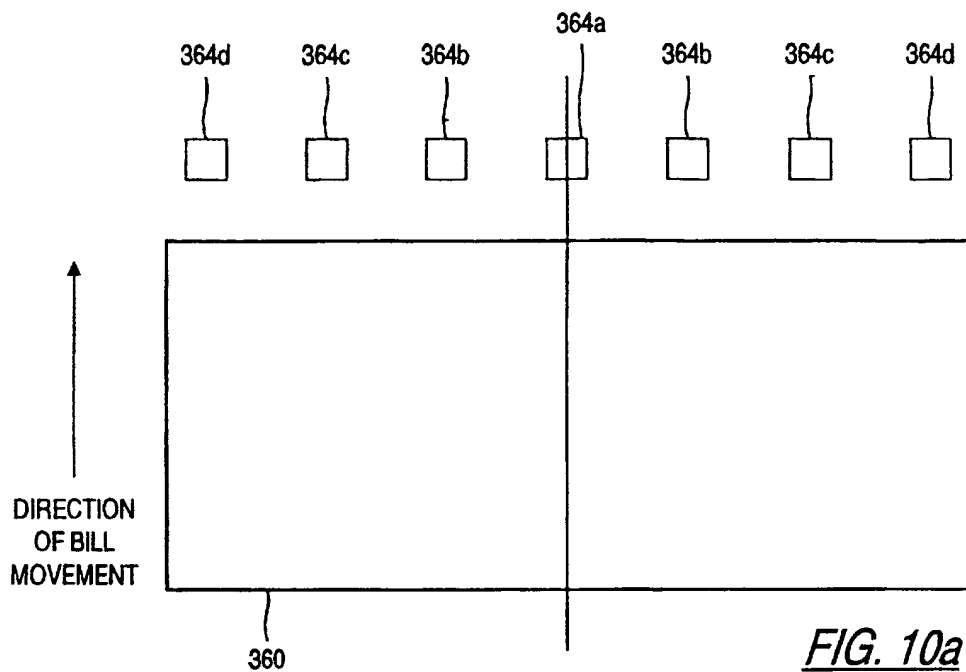


FIG. 9b

8/29





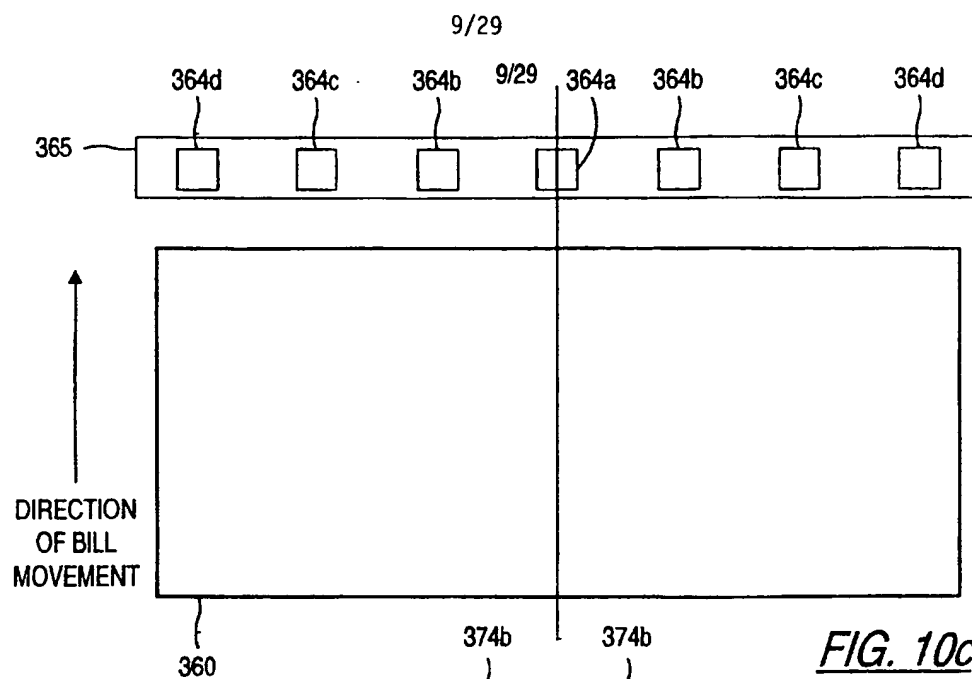


FIG. 10c

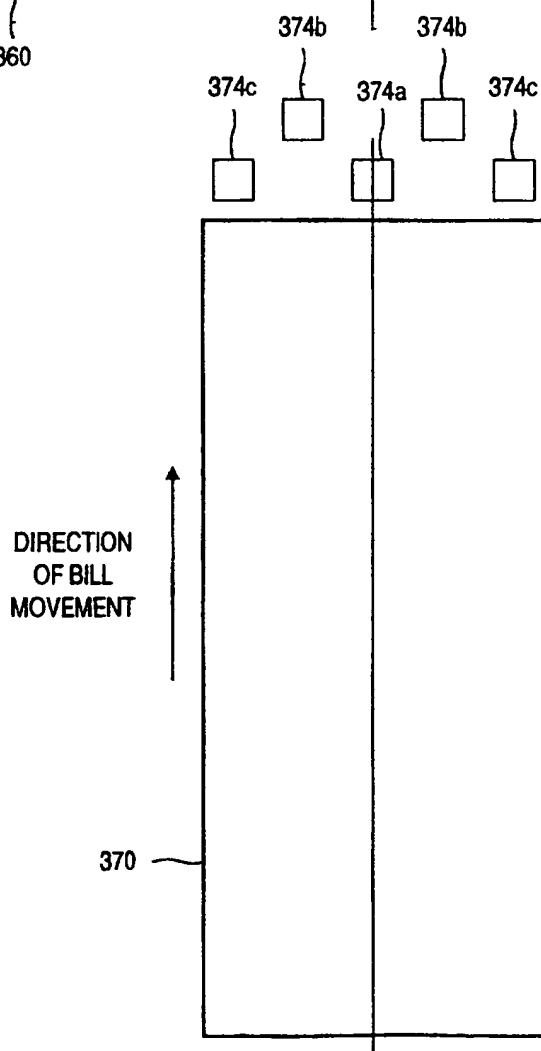
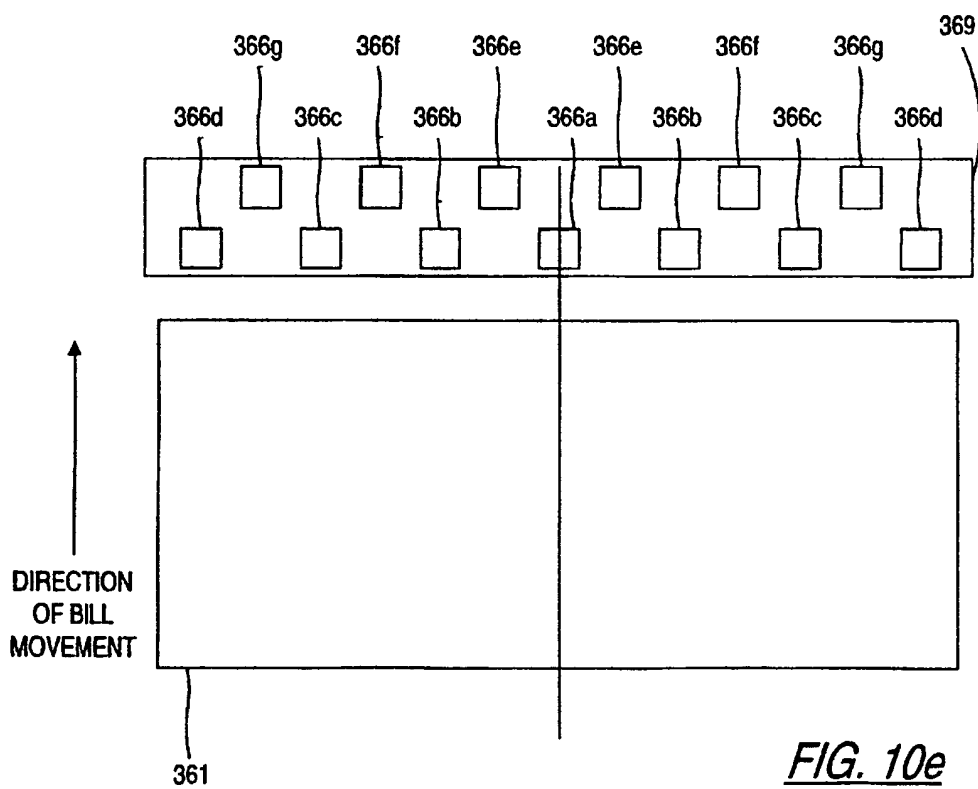
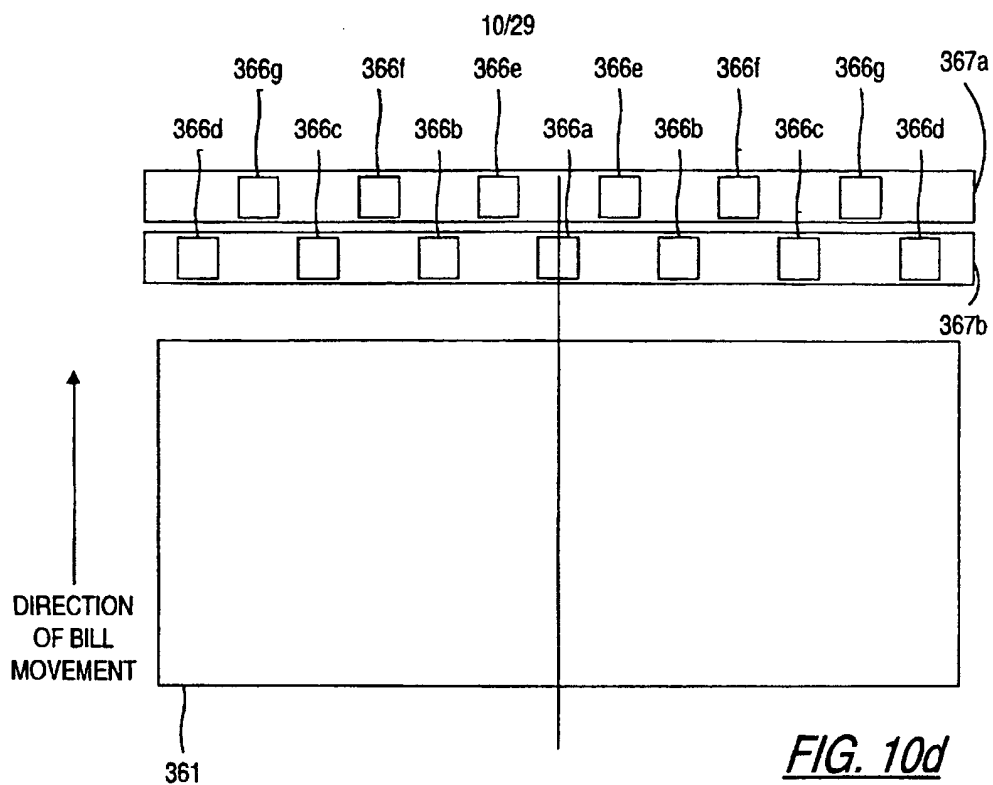
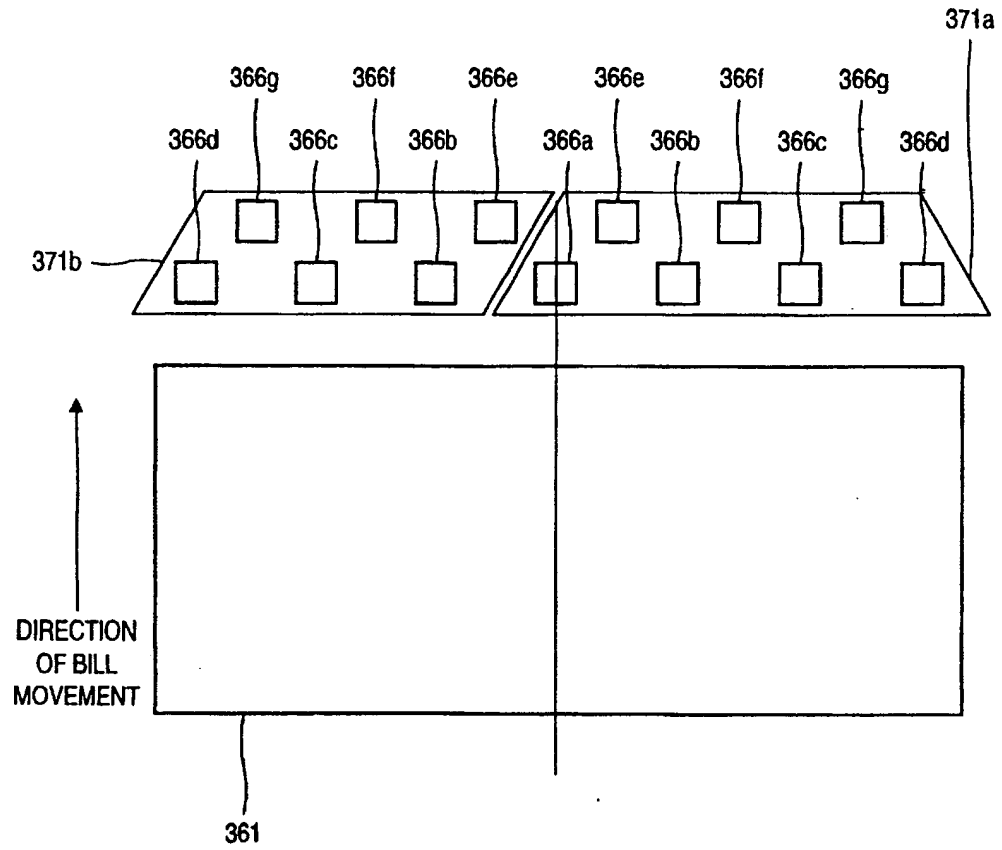


FIG. 11

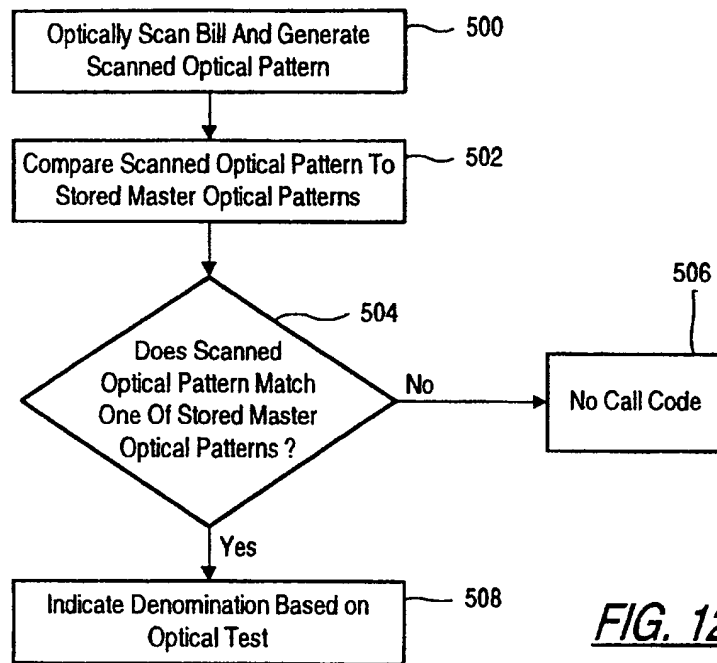
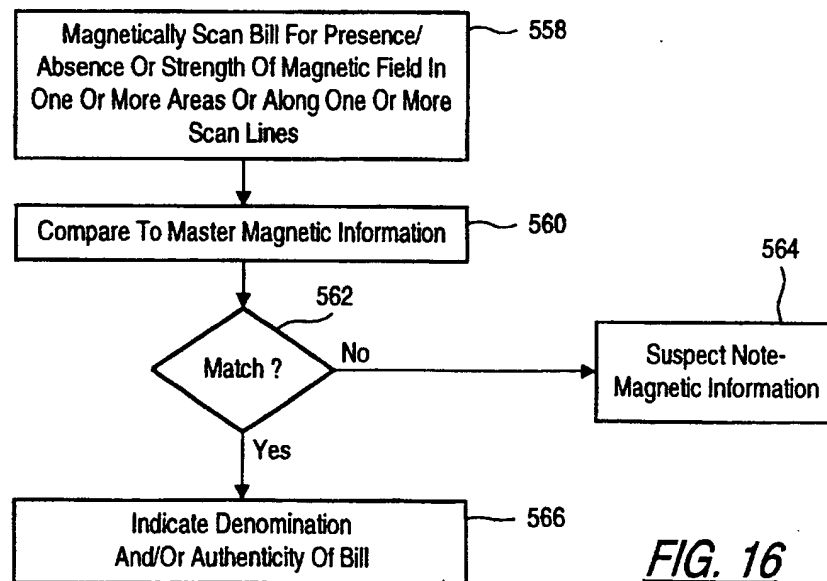


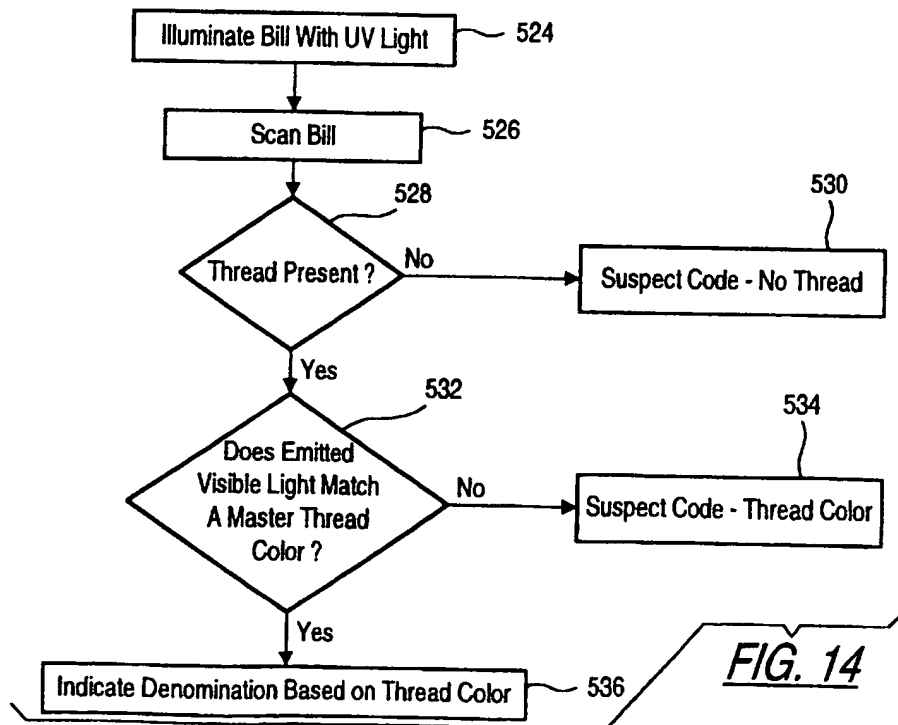
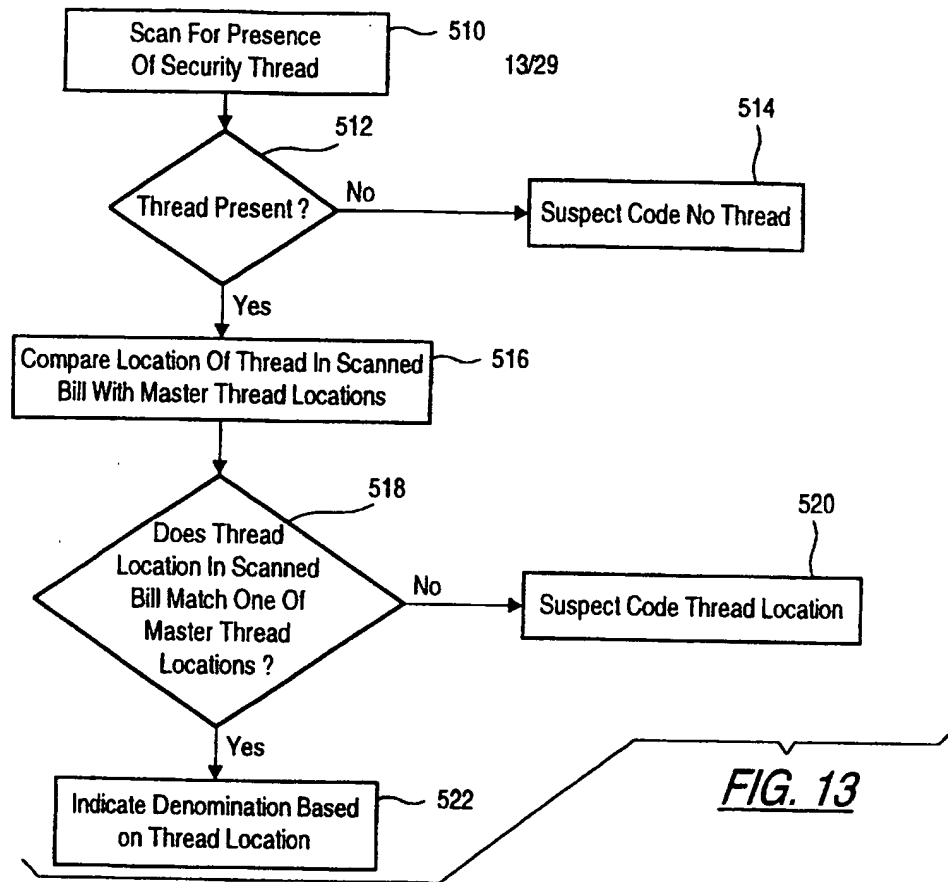
11/29



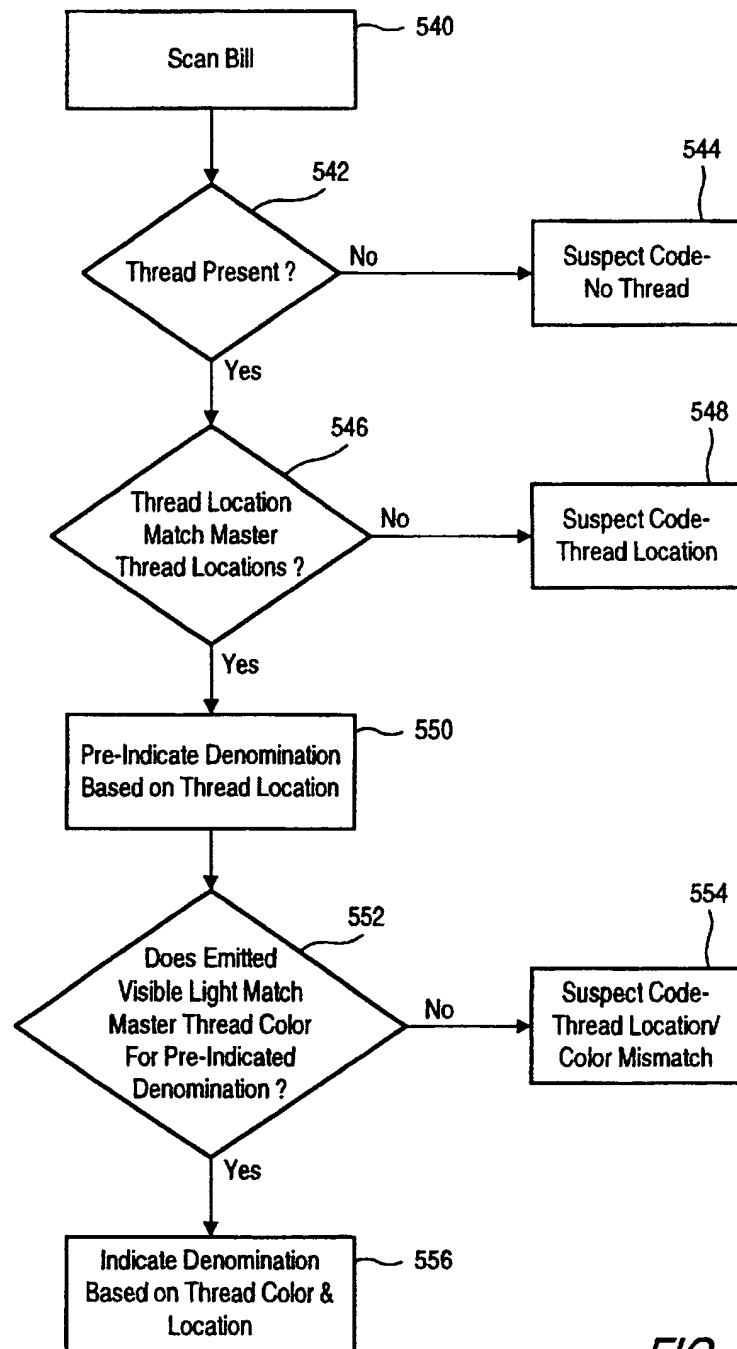
***FIG. 10f***

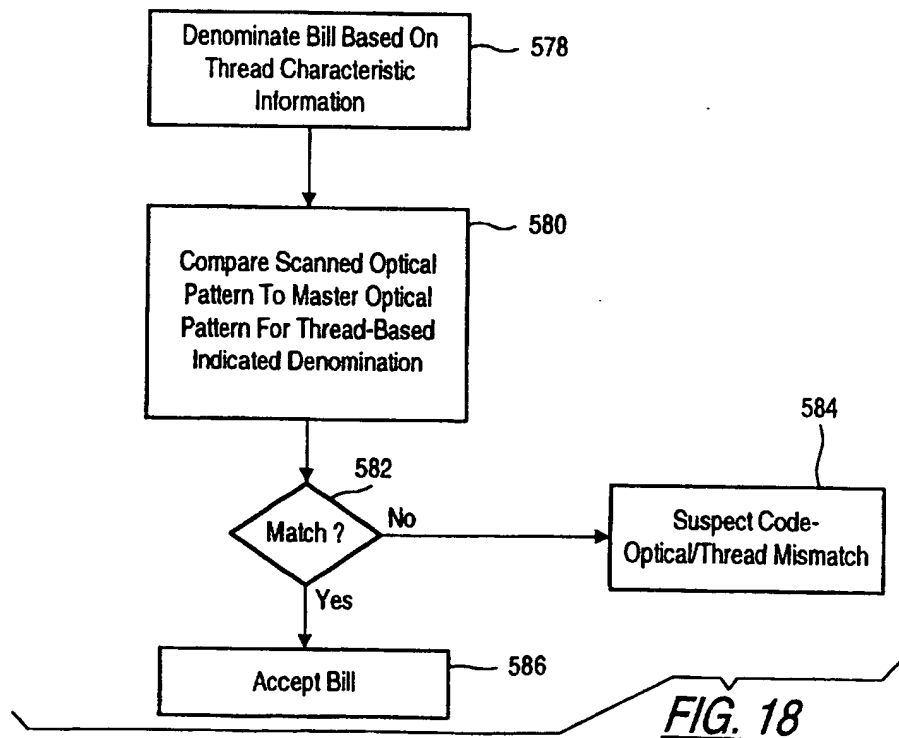
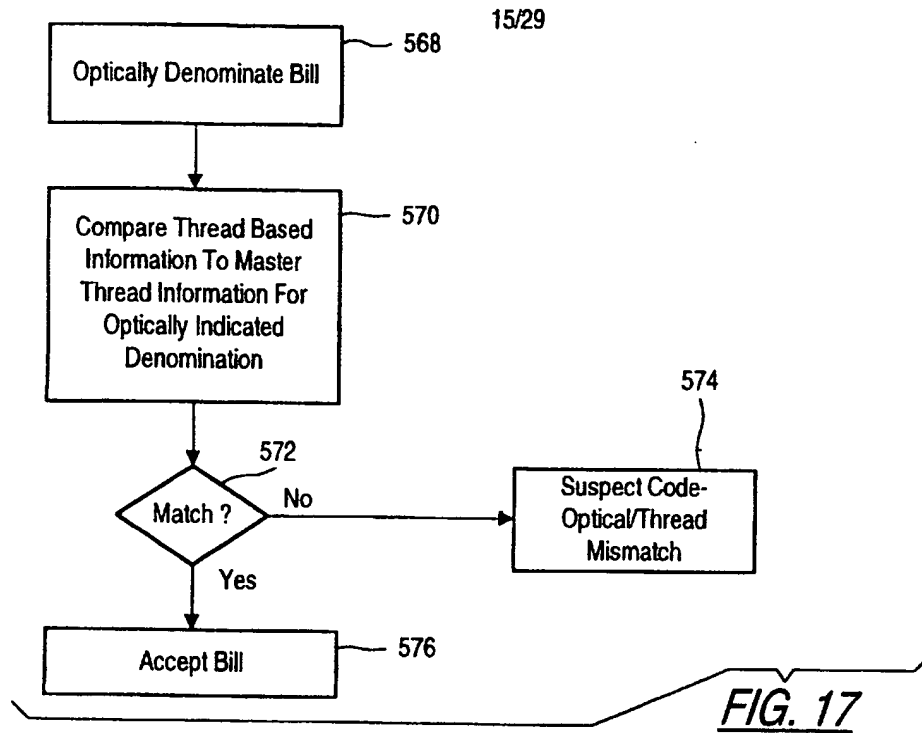
12/29

*FIG. 12**FIG. 16*

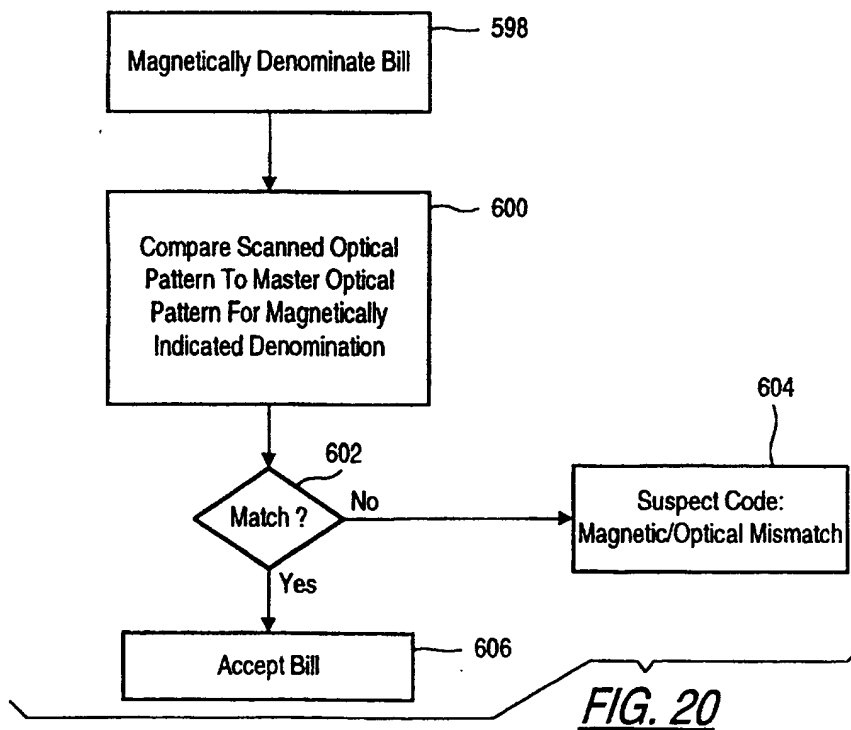
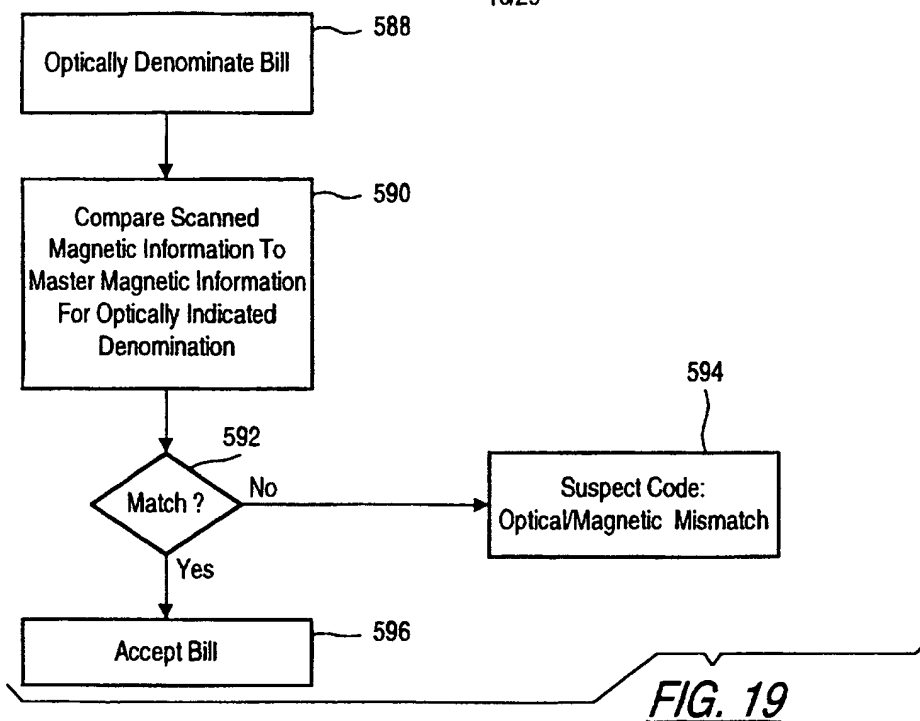


14/29

**FIG. 15**

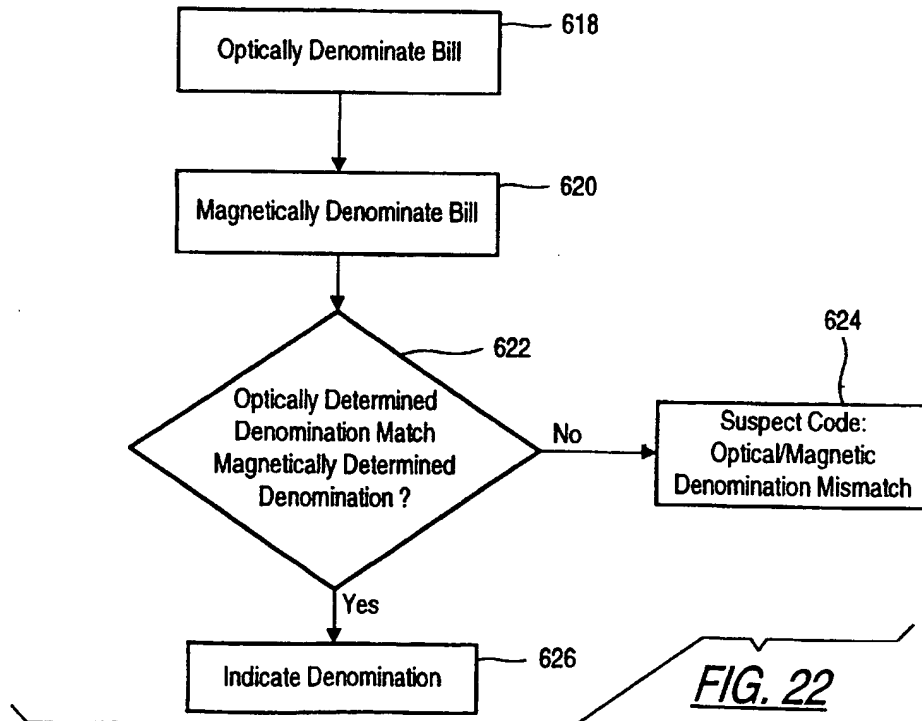
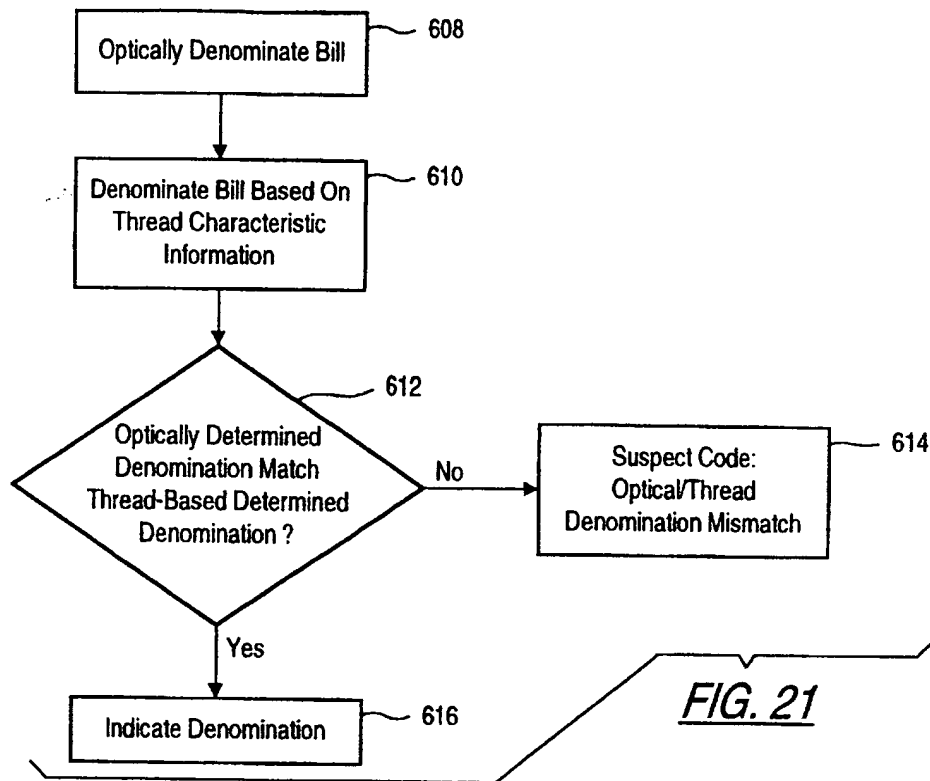


16/29

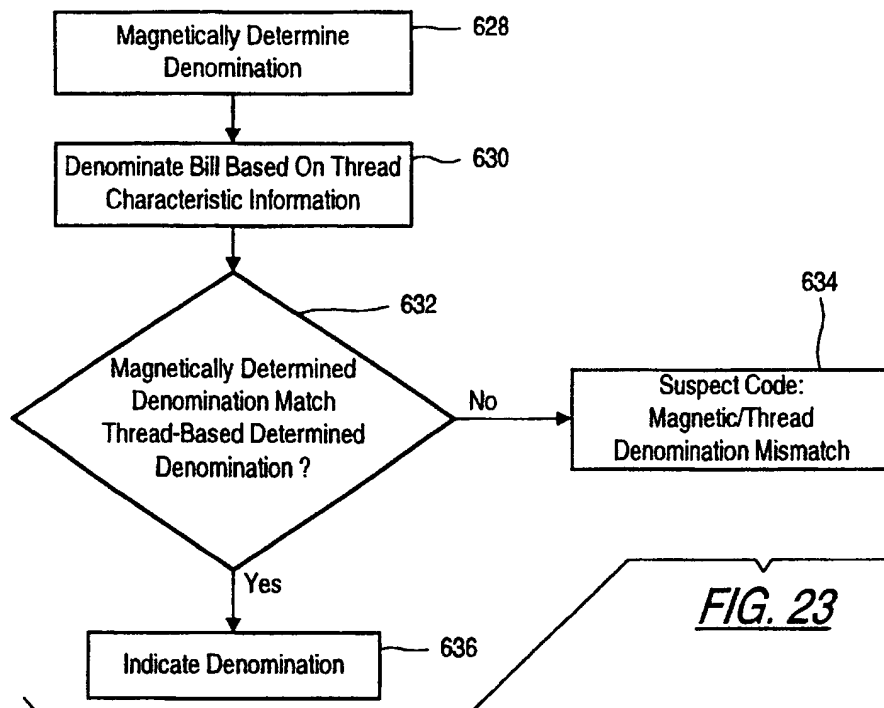
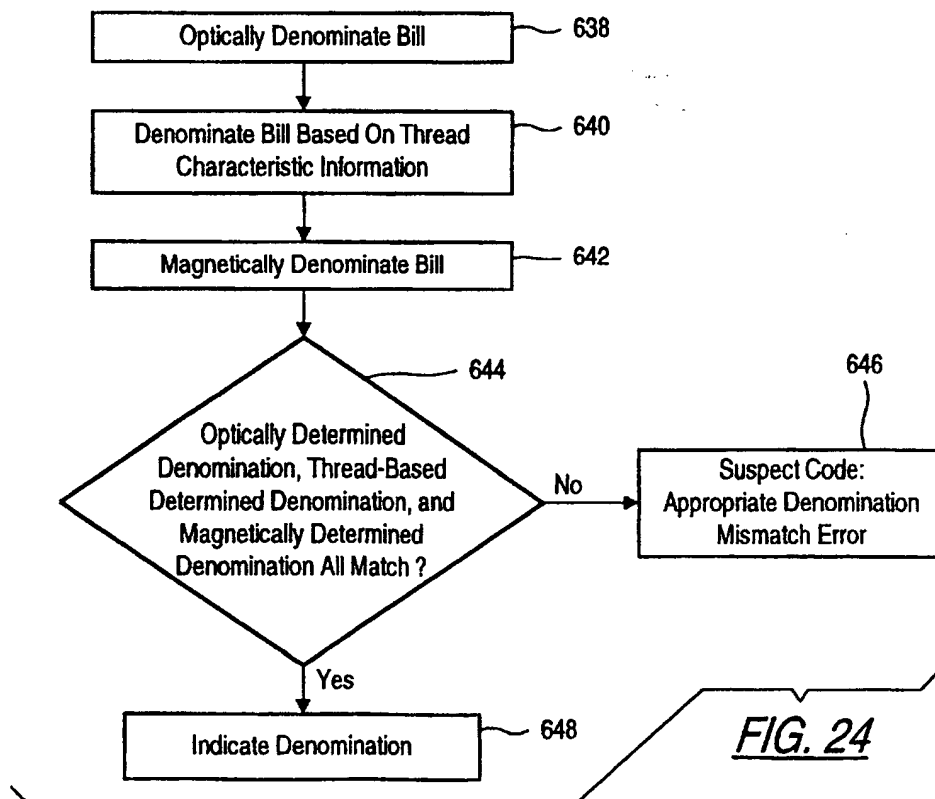




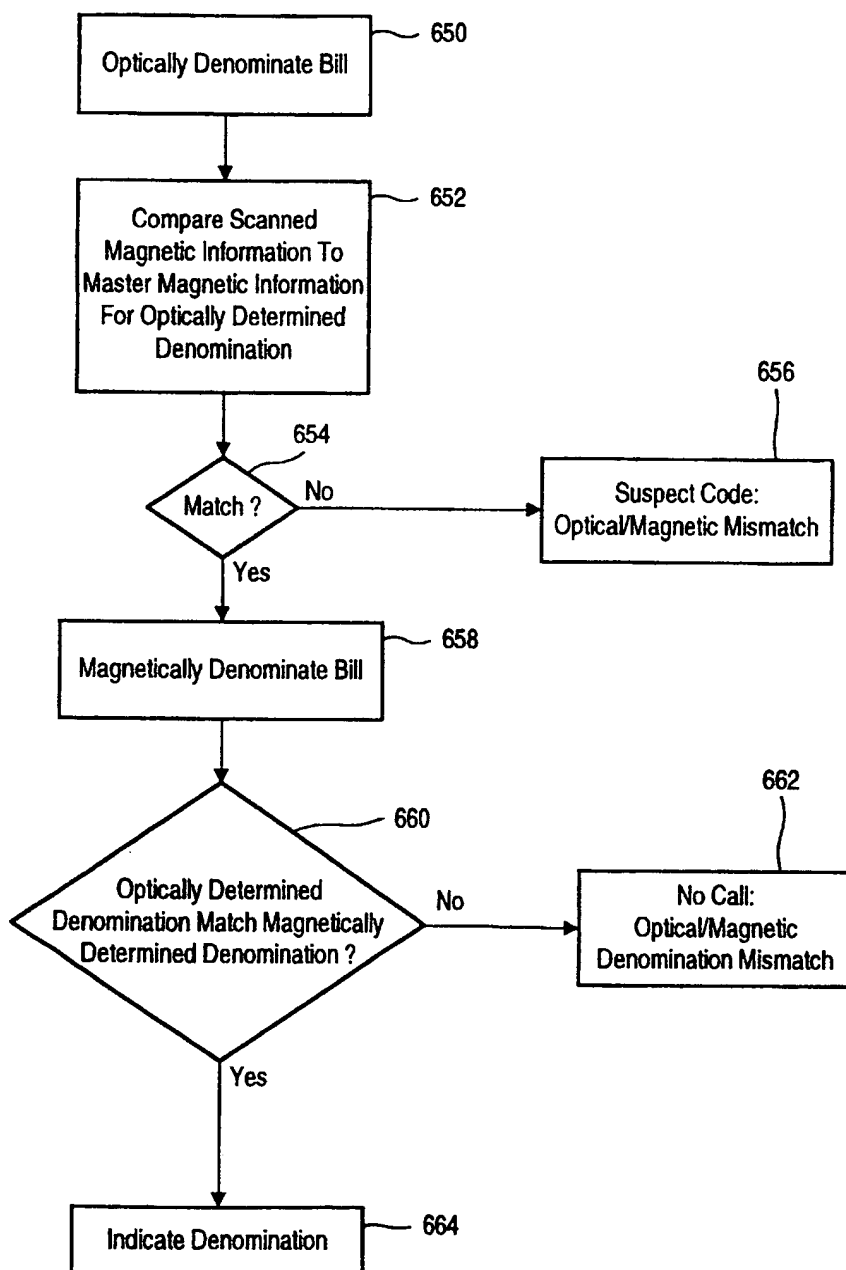
17/29



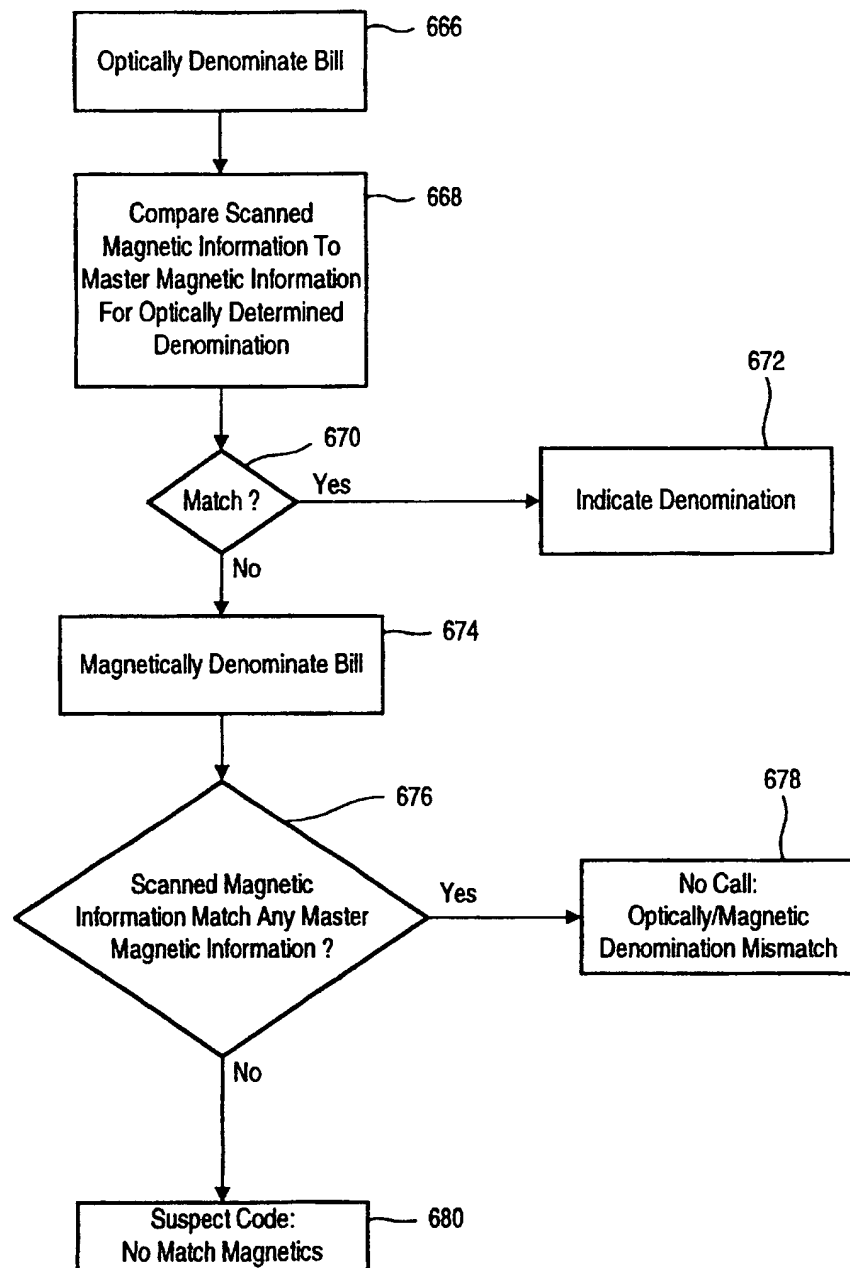
18/29

*FIG. 23**FIG. 24*

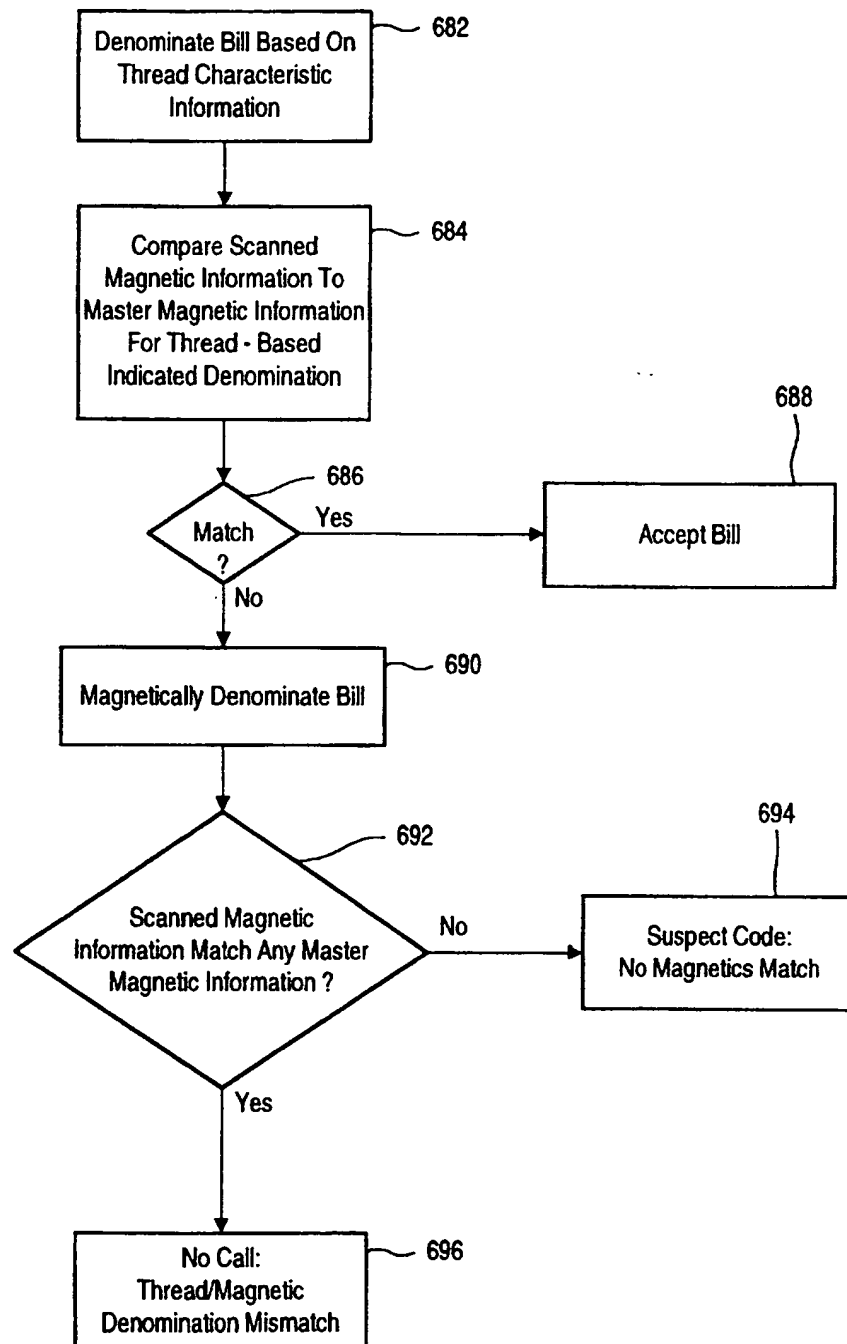
19/29

***FIG. 25***

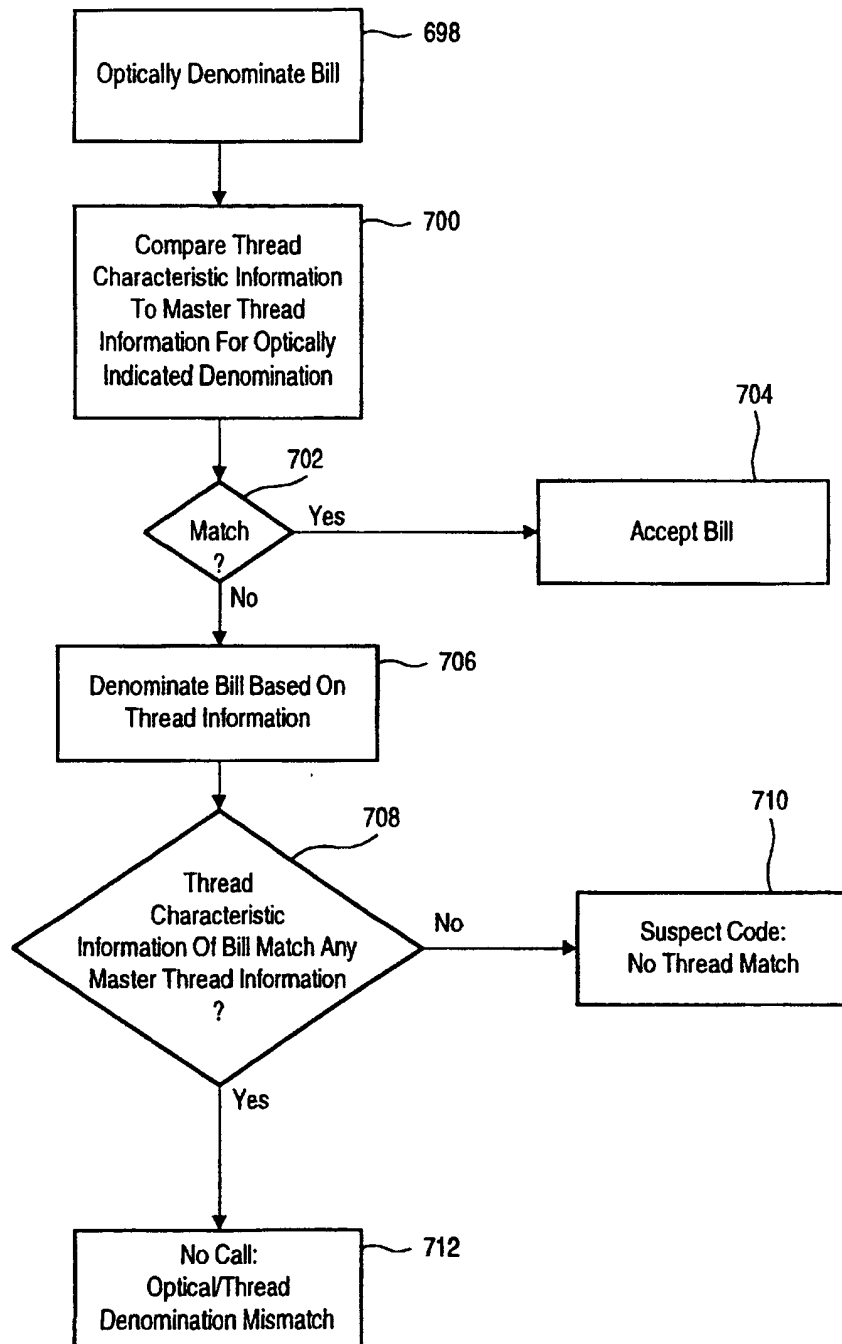
20/29

*FIG. 26*

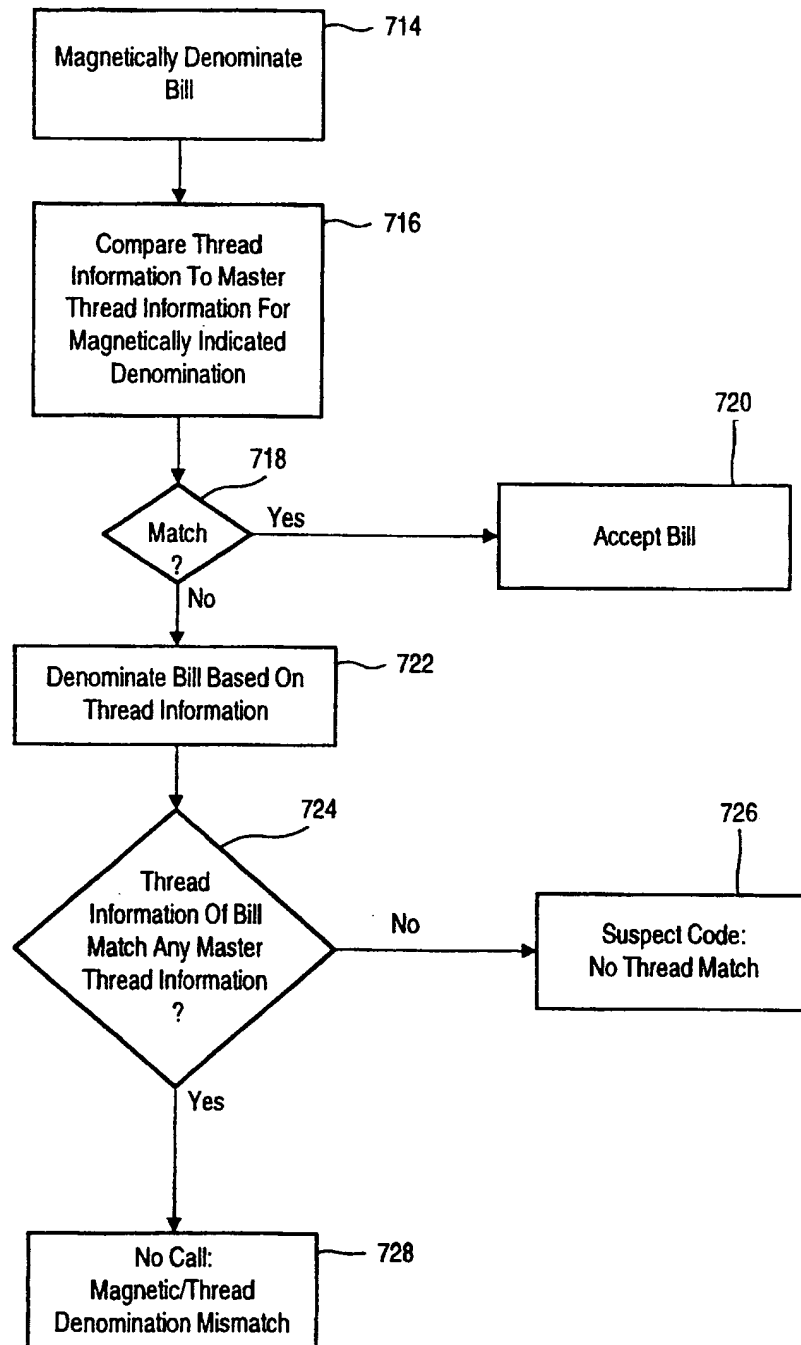
21/29

***FIG. 27***

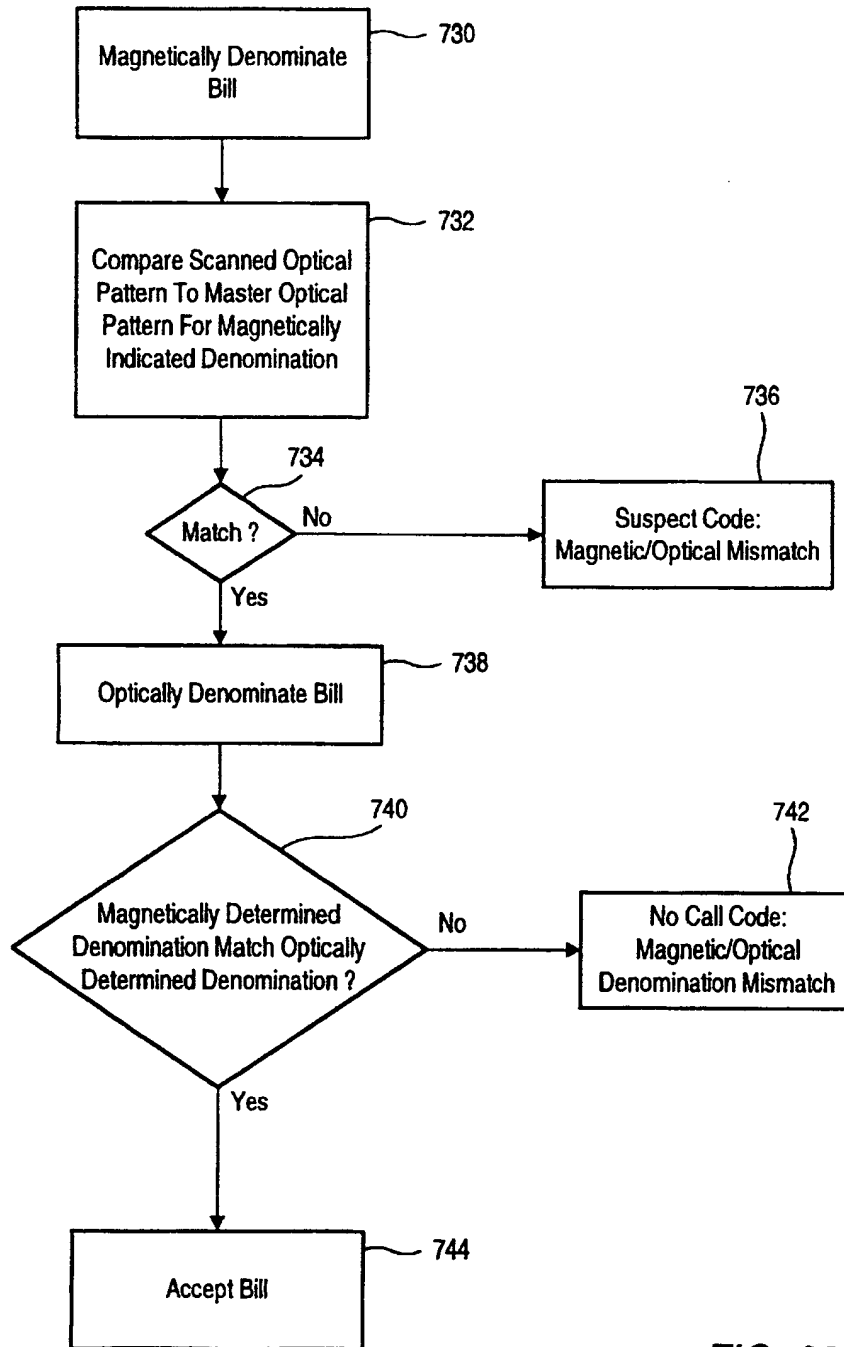
22/29

*FIG. 28*

23/29

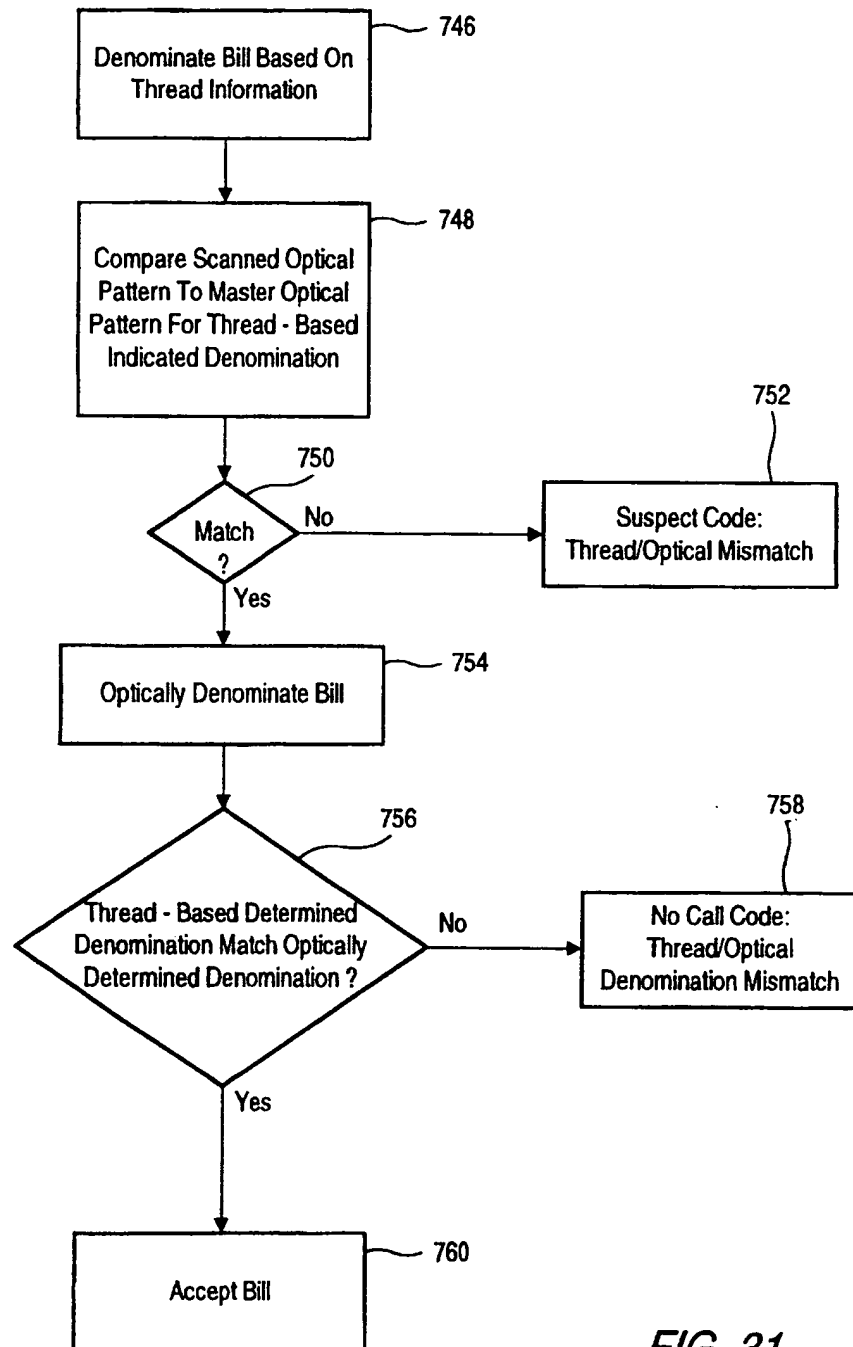
**FIG. 29**

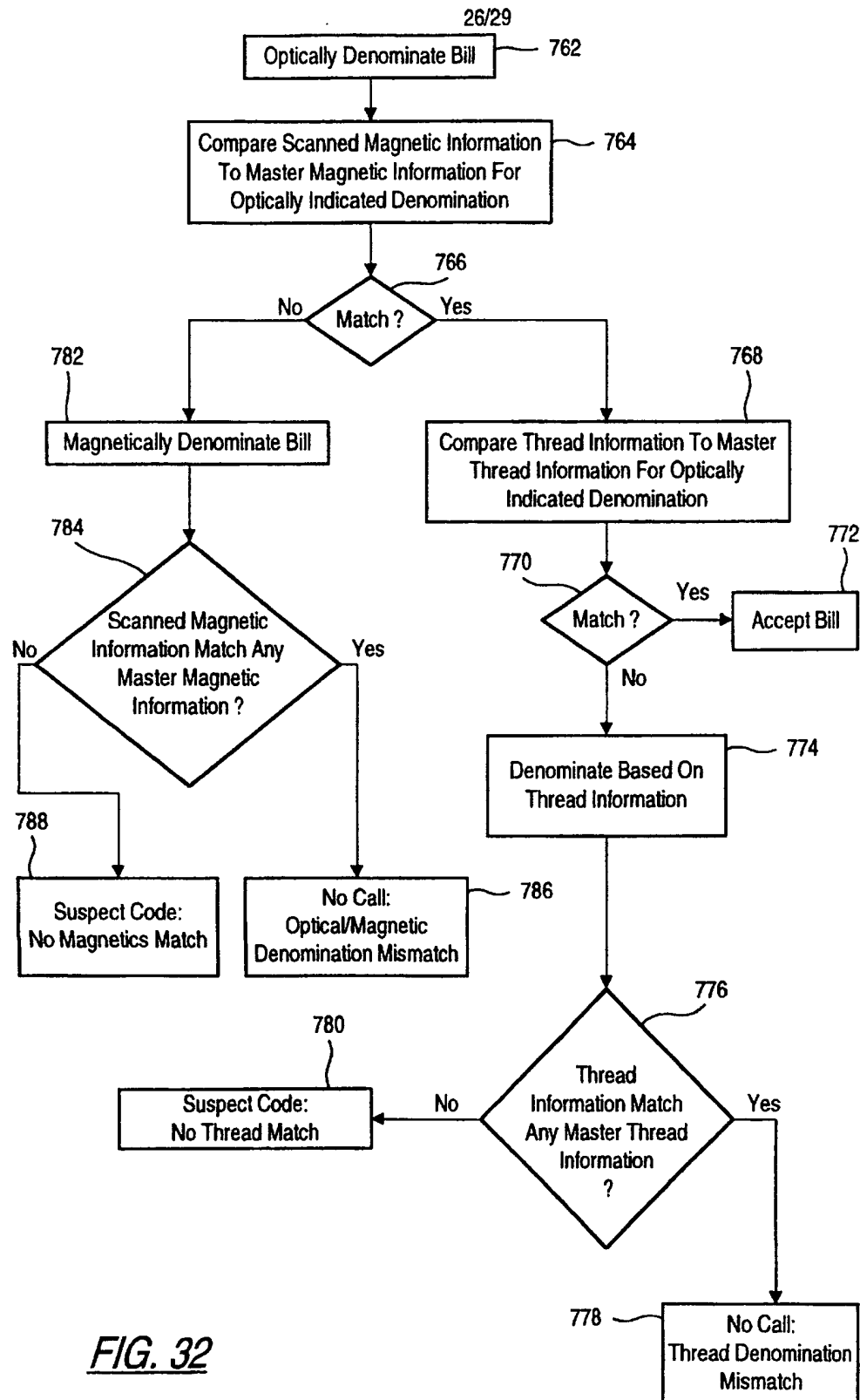
24/29

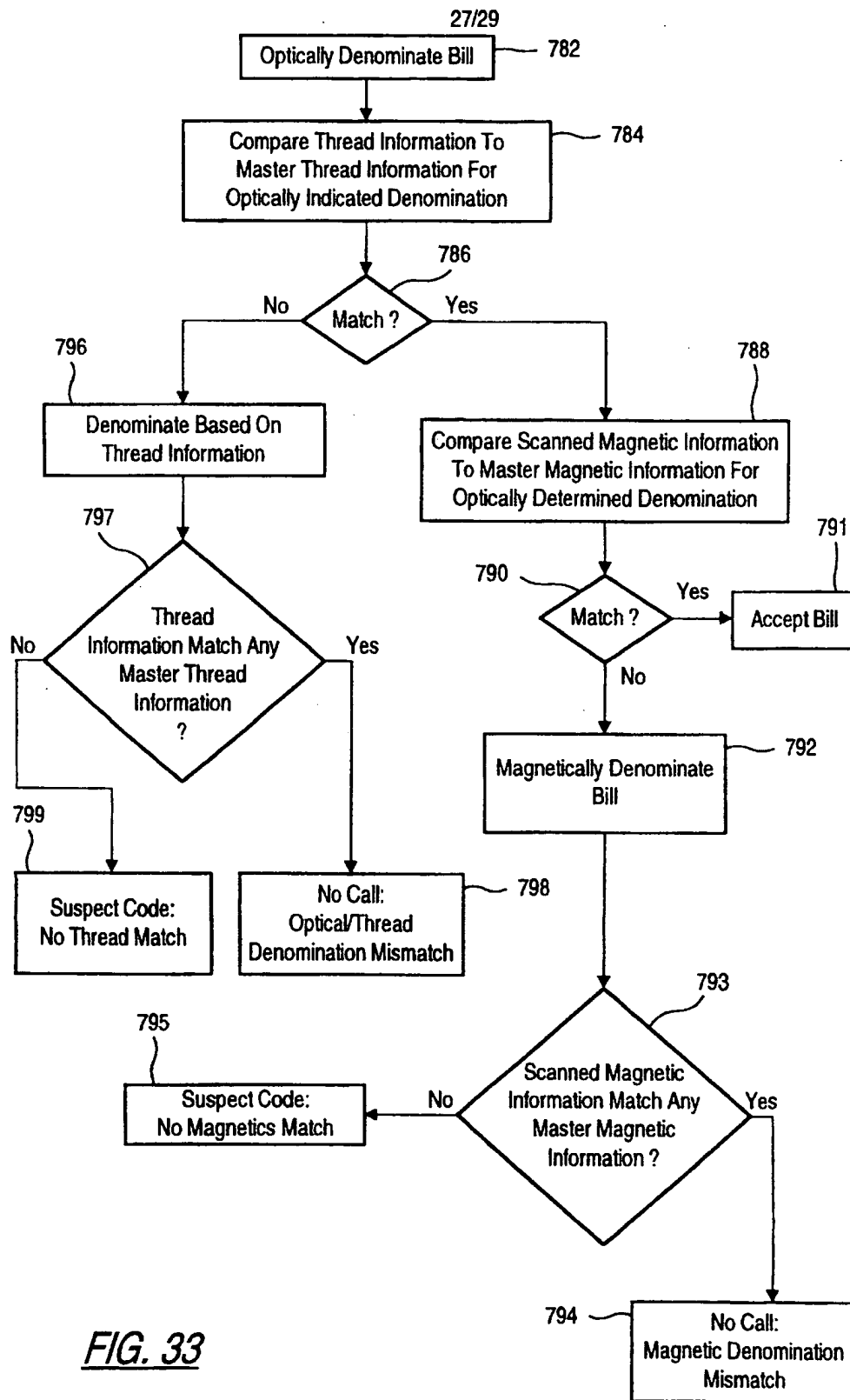
*FIG. 30*

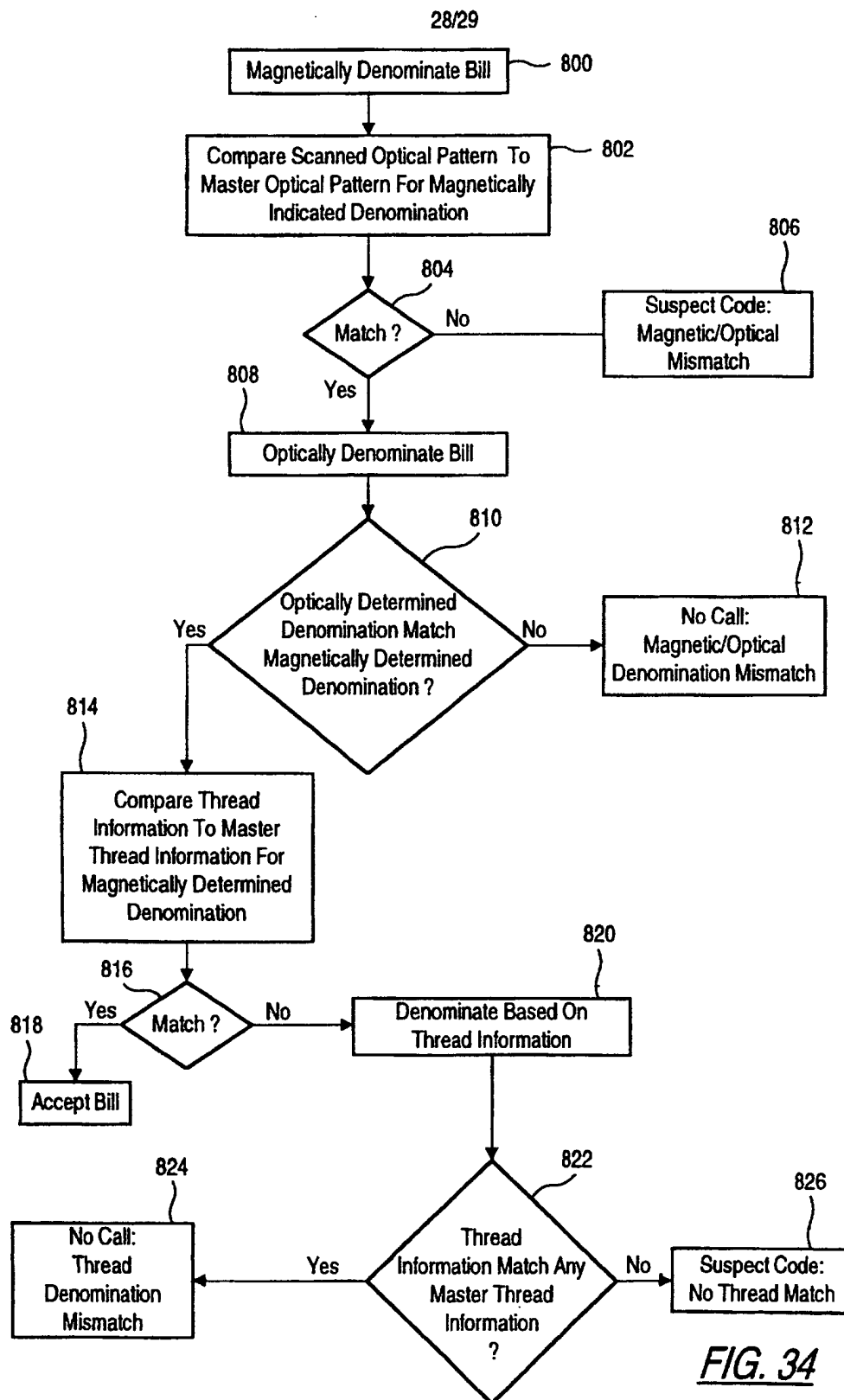


25/29

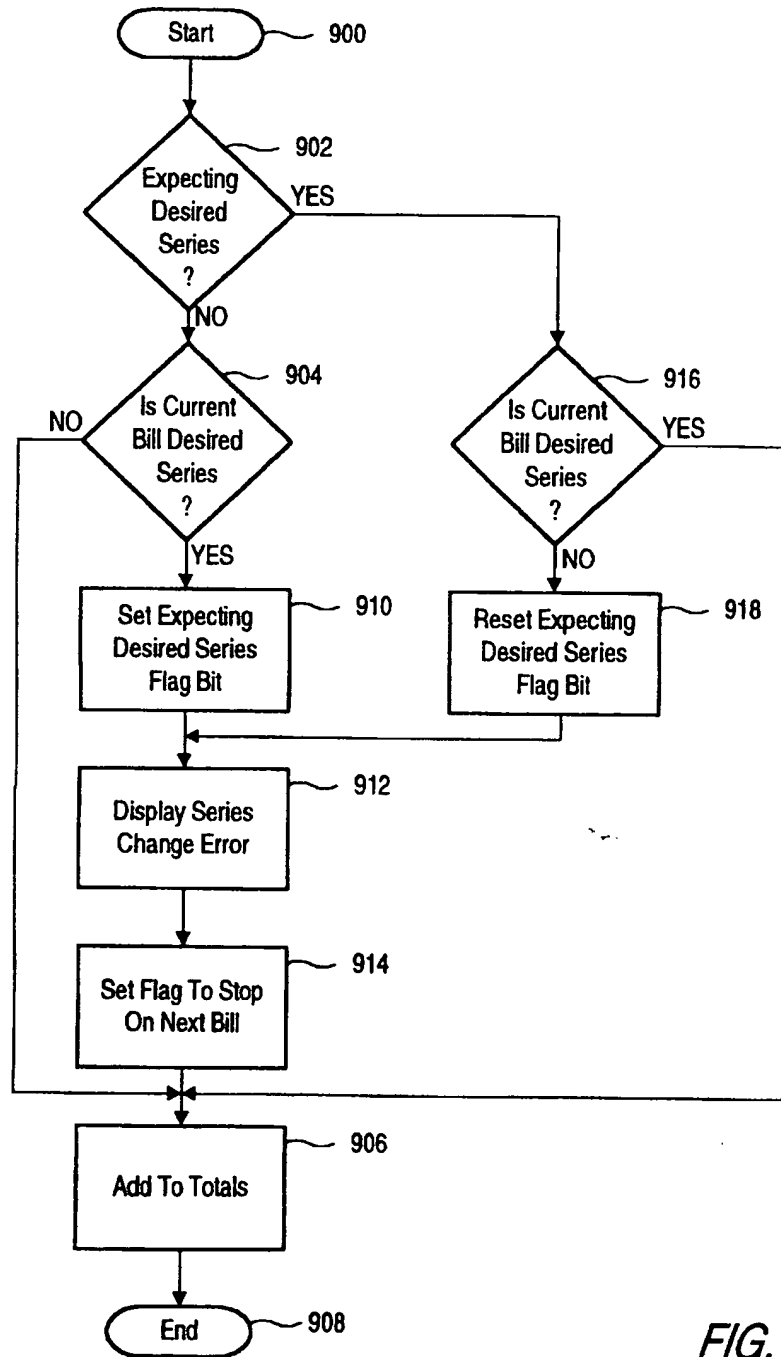
***FIG. 31***

**FIG. 32**

**FIG. 33**



29/29

*FIG. 35*

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/02301

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : G07D 7/06

US CL : 194/207

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	WO, A, 87/06041 (Rothfjell) 08 October 1987 page 9, line 20 to page 10, line 3 and page 11, lines 6-21.	1-4,7-10, 12 ----- 5,11,13
Y	US, A, 5,304,813 (DeMan) 19 April 1994 col. 4, lines 42-61.	5
X ----- Y	US, A, 4,442,541 (Finkel et al) 10 April 1984 col. 4, line 26 to col. 5, line 29.	6,14-20 ----- 11, 13
Y	US, A, 5,358,088 (Barnes et al) 25 October 1994 col. 8 lines 5-53.	21-23

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	* T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
* A* document defining the general state of the art which is not considered to be of particular relevance	* X	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
* E* earlier document published on or after the international filing date	* Y	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
* L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	* A*	document member of the same patent family
* O* document referring to an oral disclosure, use, exhibition or other means		
* P* document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

11 APRIL 1997

Date of mailing of the international search report

30 APR 1997

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

F. J. BARTUSKA

Telephone No. (703) 308-1111

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/02301

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,E	US, A, 5,607,040 (Mathurin) 04 March 1997 col. 9, line 64 to col. 10, line 50.	24-26
Y	US, A, 5,295,196 (Rateman et al) 15 March 1994 col. 5, lines 49-63.	21-26

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US97/02301

## B. FIELDS SEARCHED

Minimum documentation searched  
Classification System: U.S.

194/207

194/206,207; 209/534; 250/556;

356/071; 382/135